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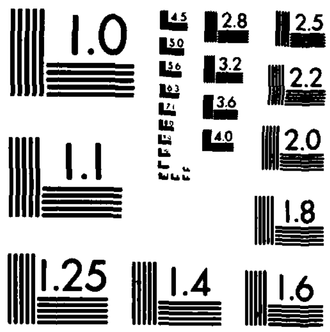
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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This is a quarterly publication presenting articles covering recent developments in East Asian (particularly Japanese) scientific research. It is hoped that these reports (which do not constitute part of the scientific literature) will prove to be of value to scientists by providing items of interest well in advance of the usual scientific publications. The articles are written primarily by members of the staff of ONR Far East,

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High Strength Low Alloys (HSLA) Steels
Cryogenic Materials
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Nuclear Demagnetization Cooling
Electronic Ship Propulsion
Cryogenic Research
Wavelength
Electrons
Surface Physics
Electrode Reactions
Corrosion
Government Industrial Research Institute
Surface Science Laboratories
Storage Rings
Electron Synchrotron
JAMSTEC
Shinkai 2000
Deep Sea Survey Technology
Manned Undersea Work R&D
Natsushima
Ceramic Powder Industry
Mitsubishi Metal Research Institute
Metallurgy
Powder Processing of Alloys
Atmospheric Chemistry
Chemical Kinetics
Ozone Cycle
National Institute for Environmental Studies

20. Abstract (cont.)

with certain reports also being contributed by visiting stateside scientists. Occasionally a regional scientist will be invited to submit an article covering his own work, considered to be of special interest.

CONTRIBUTORS

Richard Dolen received a Ph.D. in theoretical elementary particle physics from the California Institute of Technology in 1966, and worked as a theoretical physicist in industry until 1973, when he was invited to the University of Southern California to assist in the administration of the Division of Natural Sciences and Mathematics. He soon became involved in the computerization of many administrative functions and by 1976 joined the staff of the University Computing Center. There he was a leader in software development, specializing in combining diverse administrative systems and converting hostile programs into custom-tailored, user-friendly systems. He served as Chairman of the Hardware Selection Committee and as Associate Director of Administrative Data Processing. The study of Japanese led to an abiding interest in the Japanese culture and a Fullbright Fellowship to the University of Tokyo in 1965. Since then Dr. Dolen has traveled many times to Japan for business and pleasure. He has produced many translations from Japanese and French as well as numerous technical translations from Russian and German. Dr. Dolen is now a consultant in information systems in the Southern California area.

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Seikoh Sakiyama, Science Advisor of ONR Far East, has had considerable industrial experience in laboratory chemistry, electronic instrumentation, and quality control methodology. His interests include computer science, linguistics, and energy technology.

CONTENTS

Cover: The Daibutsu (Great Buddha) of Kamakura, Japan. The 700-year old bronze image was originally housed in a large building on the grounds of the Kokokuin Temple, but a tsunami (tidal wave) swept the structure away and the statue has remained in the open since 1495. It is considered to be the most beautiful of the two Great Buddhas of Japan. The other, larger one is located at Nara. Photograph by Erin Moore.

SYNCHROTRON RADIATION FACILITIES IN JAPAN

Leon H. Fisher

INTRODUCTION

An electron synchrotron is a device for imparting extremely large energy, hundreds of MeV's to tens of GeV's or more, to electrons moving in either circular or other closed planar orbits (consisting of alternate circular and linear sections). Magnetic fields are used to make the electrons move in nonlinear paths. Electrons are generally injected into the device at energies relatively low compared to the terminal energy but still high enough so that they initially have relativistic velocities. Additional energy to bring the electrons up to the terminal energy is supplied by high frequency electric fields within the synchrotron. The original purpose of electron synchrotrons was to use the resulting energetic electrons in physical experiments. The production of energetic particles is still the only use of synchrotrons imparting energy to particles more massive than the electron.

All charged particles emit electromagnetic radiation if their velocity is changing in magnitude and/or direction. Thus, even after the particles in a synchrotron have been brought up to terminal energy, they radiate when they are made to travel in nonlinear paths. In a sense, synchrotron radiation by electrons is analogous to bremsstrahlung where the nuclear electric field causing electrons to undergo acceleration is replaced by the magnetic field of the synchrotron. In synchrotrons, the power radiated increases strongly with increasing particle energy and decreasing rest mass. Practically, synchrotron radiation is only appreciable for electrons. (Recently, synchrotron radiation has been observed from protons in the Intersecting Storage Ring (ISR) at CERN [Organisation Européenne pour la Recherche Nucléaire.) The radiation associated with relativistic charged particles moving in curved orbits due to magnetic fields is called synchrotron radiation whether the radiation is produced by a synchrotron or not. (Synchrotron radiation from extraterrestrial sources have been identified with sunspots, the Crab nebula, etc.)

In some cases, the "waste" product radiation resulting from electron synchrotrons built for producing high energy electrons has been used for research purposes. However, the interest in producing and using intense radiation as a research tool in itself has resulted in the building of many electron devices dedicated to producing intense radiation without concern for using the resulting high energy electrons. Such devices are designed specifically for producing intense radiation and constitute a kind of "storage ring" in which electrons circulate for long periods, perhaps as much as hours, emitting radiation and having the radiated energy lost by the electrons replenished by rf energy, usually in one of the linear sections. (Other kinds of storage rings, such as the ISR mentioned above, are not primarily used for producing radiation, but are used to store particles for use in studying particle-particle interactions.) Storage rings for producing synchrotron radiation must have electrons injected into them from either an auxiliary electron linear accelerator or an auxiliary electron synchrotron. The electrons which are injected into the storage ring have energies either close to the storage energy or have a sizable fraction of the storage energy. As already mentioned, when the electrons are injected at a lower energy than the storage energy, provisions are made to increase their energy within the storage ring to the terminal energy by means of high frequency electric fields. In general, electron storage rings consist of a number of linear sections with a bending magnet between each two adjacent linear sections. It is while the electrons are being bent by the magnetic fields that they emit radiation.

The current widespread interest in synchrotron radiation is illustrated by the special issue of *Physics Today, 34,* (5), (1981) completely devoted to synchrotron radiation,

the Joint Symposium of the American Physical Society and the American Association of Physics Teachers, "Synchrotron Radiation: Now and Future," held in January, 1982, and by a continuing spate of articles and books. Two recent examples of such books and articles are "Surface Spectroscopies with Synchrotron Radiation," by N. V. Smith and D. P. Woodruff, *Science, 216,* 367 (1982) and a 750-page book *Synchrotron Radiation Research,* edited by H. Winick and S. Doniach, Plenum Press, 1980, respectively. Electron storage rings specially designed for emitting synchrotron radiation (and when necessary, electron preacceleration and injection facilities) have been and are being widely constructed in developed countries. Such sources emit a continuum and are extremely bright.

The wavelength range of intense synchrotron radiation emitted by an electron synchrotron or by an electron storage ring depends on the particular device and the conditions under which it is operated. Present devices have useful lower wavelength limits ranging from about 0.1 Å to about 30 Å. The useful upper wavelength limit may be in the visible or the infrared. Often the radiation output of an electron storage ring is characterized by a critical frequency, or a critical energy (the energy in electron volts of the critical frequency) or a critical wavelength (the wavelength corresponding to the critical frequency). The critical frequency relates to the fact that the spread of the synchrotron radiation beam transverse to the orbital plane decreases with increasing frequency and that at about the critical frequency this vertical angular spread in radians is about the reciprocal of the ratio of the particle energy to its rest energy. About half of the energy of the emitted spectrum is above and about half below the critical frequency (or critical energy or critical wavelength). The critical wavelength is about two and a half times the wavelength of the maximum in the brightness-wavelength curve associated with the device, or, alternately, the critical photon energy is about 0.4 of the energy of the photons at the brightness peak. The brightness of such sources are a few hundred to ten thousand times as large as conventional sources previously available for comparable wavelengths.

Synchrotron radiation possesses a number of characteristics desirable for research; for example, stability, strong collimation (already alluded to in the previous paragraph), almost complete linear polarization in the orbital plane of the circulating electrons (i.e., polarization at right angles to the magnetic field), and the fact that the radiation consists of nanosecond pulses. Intense highly monochromatic radiation of any wavelength between the x-ray and infrared regions can be obtained from the continuum synchrotron radiation using gratings or crystal monochromators (providing the electron synchrotron or electron storage ring supplies intense radiation in the appropriate wavelength regions).

Synchrotron sources provide intense radiation at wavelengths for which laser sources are either unavailable (above photon energies of a few kilovolts or photon wavelengths less than about 5 Å) or for which tunable lasers (extreme ultraviolet and soft x-rays) are not available. However, laser sources can be brighter than synchrotron radiation sources for certain wavelength regions.

Synchrotron radiation is essentially incoherent. However, synchrotron radiation can be made to be partially coherent by the use of devices known as "undulators" which provide space periodic magnetic fields over relatively short regions in the linear sections leaving the trajectories of the electrons when they leave the undulator the same as when they entered the undulator. Because of this partial coherence, undulators enhance the brightness of specific wavelengths. Undulators and associated magnetic devices known as wigglers (also used in electron storage rings) have been discussed by H. Winick, *et. al.* in *Physics Today, 34,* 50 (1981).

Aside from the basic research in many fields which can be carried out with synchrotron radiation, another justification for building electron storage rings dedicated to producing radiation is that they might eventually be used commercially for x-ray photolithography in the manufacture of LSI semiconductor devices. At present, ultraviolet lithography is being used to fabricate such devices and no companies have decided to use x-rays as yet. Even if x-ray photolithography were to be adopted for producing such semiconductor devices commercially, x-ray synchrotron radiation sources would have to compete with other intense x-ray sources such as those emitted when a strong laser beam irradiates a solid target.

A paper, "Synchrotron Radiation Research in Japan," by H. Winick appeared in this *Bulletin*, *3*, (4), October to December 1978. Winick discussed the 400 MeV Synchrotron Orbital Radiation electron storage ring (SOR-RING) dedicated to synchrotron radiation spectroscopy which is located at the Institute for Nuclear Study (INS) and which has been operating since 1974. INS, which is part of the University of Tokyo, is located in the city of Tanashi, Tokyo metropolitan area, about 20 miles west of central Tokyo.

Winick's paper also contained an Appendix, "Outline of Photon Factory Project," which described a 2.5 GeV electron storage ring then just beginning to be constructed by KEK (Koh Energiibutsurigaku Kenkyusho, Koh = high, butsurigaku = physics, kenkyusho = institute), the Japanese National Laboratory for High Energy Physics. KEK is located in Tsukuba, the new Japanese science city, located about 50 miles northeast of Tokyo. [Those interested in learning more about Tsukuba should read "Tsukuba Science City: Japan Tries Planned Innovation," by J. L. Bloom and S. Asano, *Science*, *212*, 1239, (1981)] This machine was scheduled to begin operating in the summer of 1982. The first photons were actually produced in a series of tests in February and March of 1982. Regular operation started in June 1982. The installation is known as KEK-PF, or PF, or more popularly as the Photon Factory.

Winick stated that Japan was planning two other dedicated synchrotron radiation sources. One of these was to be a 600 MeV storage ring which had been proposed by the Electrotechnical Laboratory (ETL). (ETL, which carries out a broad range of research and development programs with a research staff of about 500, is one of sixteen research institutes operated by the Industrial Science and Technology Agency of the Ministry of International Trade and Industry (MITI, pronounced mee-tee). Until two years ago, all ETL activities, except one installation in Osaka, was housed in Tanashi (the same city in which INS is located). Now all ETL activity, with the exception of the Osaka branch, is housed in Tsukuba. Plans for moving had been in progress for ten years prior to the actual move, an example of Japanese long-range planning. No plans, however, were made for the use of the vacated space and buildings and they lie unused and vacant in Tanashi. MITI is considered to be one of the most influential government agencies in Japan and has tremendous influence on industry and foreign trade. It is the agency charged with determining and administering industrial policy in Japan. A day does not go by in which an important announcement by MITI does not appear in the newspapers. As this is being written, an article appeared on the front page of the *Japan Times* entitled, "MITI Urged to Push Plutonium as Fuel." There is no analogue of MITI in the United States. It is often referred to by foreigners in Japan as "Mighty MITI." It may come as a surprise to some readers that MITI is also heavily involved in research and development. Those interested in learning more about MITI may want to read Chalmers Johnson's (Professor of Political Science at the University of California, Berkeley) *MITI and the Japanese Miracle* Stanford University Press, 1982. This book, however, does not discuss any of the activities of the Industrial Science and Technology Agency.) The ETL synchrotron radiation facility has essentially been completed and is now producing synchrotron radiation. Winick stated that

the other proposed synchrotron radiation source was a 200-300 MeV electron storage ring which had been proposed by the Institute for Molecular Science (IMS), (Bunshikagaku Kenkyusho, bunshi = molecular, kagaku = science), a national facility located in the city of Okazaki. The Okazaki synchrotron radiation facility is under construction and is scheduled for completion in March of 1984. In fact, electrons will be stored at 600 MeV rather than at 200-300 MeV. The facility is to be known as UVSOR (Ultraviolet Synchrotron Orbital Radiation) and will consist of a 15 MeV electron linear accelerator whose electrons will be injected into a 600 MeV electron synchrotron with transfer of the resulting electrons into the storage ring.

Subsequent to the publication of Winick's paper in this *Bulletin*, a U.S.-Japan seminar entitled, "Synchrotron Radiation Facilities," was held in Honolulu, November 5-9, 1979. (U.S.-Japan seminars are supported by the U.S.A.-Japan Cooperative Science Program of the NSF and the Japan Society for the Promotion of Science.) K. Kohra, the director of the Photon Factory, was the Japanese coordinator of the seminar. The proceedings of the seminar constituted an entire issue of *Nuclear Instruments and Methods, 177*, (1), (1980). Out of 36 papers, 13 were from Japan. Of these 13, eight related to the Photon Factory and three to the SOR-RING at Tanashi.

It was thought useful to update Winick's report and to describe briefly the present status of synchrotron radiation facilities in Japan and to give an idea of the research which has been, and which is being, and will be, carried out with these facilities. In connection with the present report, site visits were made to all three synchrotron radiation sources now operating in Japan, i.e., the SOR-RING, the ETL facility, and KEK's Photon Factory. The facilities are now discussed and their important parameters are given in the Tables.

SYNCHROTRON RADIATION LABORATORY-INSTITUTE OF SOLID STATE PHYSICS (SRL-ISSP)

ISSP is part of the University of Tokyo and has its headquarters at the Roppongi Campus of the University of Tokyo in central Tokyo, contiguous to the location of ONRFE. (This is a small campus of the University of Tokyo and also houses the University's Institute of Industrial Science, an organization largely devoted to technology transfer from university to industry after WW II. It has gradually developed basic research engineering fields and is introducing new technology as well. These two institutes comprise the entire activity at the Roppongi campus. No courses are offered on this campus; it is essentially a graduate and postdoctoral research center. There are two massive buildings at present on the Roppongi campus, but a third huge building is under construction.)

The Synchrotron Radiation Laboratory-ISSP (SRL-ISSP) is the formal name of the facility which includes the 400 MeV electron storage ring discussed by Winick. As already mentioned, it is housed within INS which is in Tanashi. The Director of SRL-ISSP is H. Kanzaki, a solid state physicist; his office is at the Roppongi campus of the University.

SRL-ISSP consists of the SOR-RING and, when used as an injector, a 1.3 GeV electron synchrotron and associated apparatus. The electron synchrotron began operation in 1961 and "belongs" to INS, is known as INS-ES and antedates SRL-ISSP. The SOR-RING belongs to and is operated by ISSP. It is in cramped quarters that do not provide adequate space for experimental work. Three-hundred MeV electrons are injected from INS-ES into the SOR-RING. The SOR-RING is the least bright of the three existing synchrotron radiation installations in Japan and provides the lowest useful upper frequency. UVSOR will also be brighter. Experiments with radiation from the SOR-RING are carried out from approximately 30 to 3000 Å.

SRL-ISSP has a staff of ten faculty members. It is expected that five more will eventually be added. This staff essentially operates and manages the installation. Professors, graduate students, and technicians come from universities and bring equipment to carry out experiments. SRL-ISSP is used by workers from many institutions.

- INS-ES Beam Line

In addition to the SOR-RING beam lines, one x-ray beam line of synchrotron radiation is obtained directly from INS-ES, the 1.3 GeV synchrotron, and is used by ISSP. In 1981, the INS-ES beam line was used by SRL-ISSP to investigate x-ray lithography and its application to electronic devices and to study soft x-ray luminescence of transition metal compounds and rare earth metal compounds.

- Status of the SOR-RING

Beam injection into the ring is generally made at a rate of 1 Hz and it takes about 10-30 minutes to achieve a beam current of 200-300 mA. Attempts to reduce the injection time were made by using injection frequencies from 2 to 5 Hz. Currents of about 400 m could be obtained consistently within five to ten minutes and the maximum current obtained was 510 mA (at 308 MeV). The horizontal and vertical dimensions of the elect beam are 5 mm and 1 mm, respectively. The beam life times, along with other paramete are shown in Table I.

The machine is operated four days a week for ten months a year. Injections are m three times a day, at 9:30 A.M., 1:30 P.M., and 4:30 P.M.

The SOR-RING Beam Lines

There are five sets of beam lines associated with the SOR-RING. A description of the beam lines follows.

.Beam Lines 1 and 1' (BL-1 and BL-1')

The synchrotron radiation from the first light port is divided into two parts. One is reflected upward and led to a 1 m Seya-Namioka monochromator on the floor above; this beam line is called BL-1. The other is led to a 2 m modified Wadsworth monochromator and is called BL-1'. BL-1 and BL-1' are used for spectroscopic studies in the wavelength regions of 300-3000 Å and 400-2000 Å, respectively. A 25 cm Seya-Namioka type monochromator has been constructed and installed at BL-1' as a second monochromator for studying luminescence excitation spectroscopy of rare gas solids.

.Beam Line 2 (BL-2)

The available wavelength range is from 90 to 350 Å. Most of the experiments performed so far at BL-2 have involved photoemission measurements on solid materials. A resolution of 0.16 eV at 50 eV has been attained. Surface core level shifts have been observed in InSb, GaAs, Si, and other materials.

.Beam Line 3 (BL-3)

A new plane-grating monochromator for use at BL-3 compatible with ultrahigh vacuum was constructed in 1981. This grazing incidence monochromator covers the wavelength region from 40 to 1000 Å by selecting one of the five prereflecting mirrors and the setting angle of the grating under ultrahigh vacuum conditions.

.Beam Line 4 (BL-4)

This beam line provides the highest photon energy in the facility. It is equipped with a 2 m horizontal dispersion grazing incidence monochromator whose resolution is the highest in the world, about 0.07 eV for 200 eV and this is used for observation of absorption spectra of gases.

. Beam Line 5 (BL-5)

This beam line is a free port and can be used for any purpose. Biological radiation effects have been studied extensively in the wavelength region longer than 1250 Å by use of a MgF_2 window and a Wadsworth monochromator.

The following papers were published in 1981 by workers using SRL-ISSP:

"*In Situ* Argon Glow Discharge Cleaning in the SOR-RING Vacuum System," H. Kitamura, Nuc. Instr. Meth. *177*, 107 (1980),

"Absorption Spectra of Hydrogen and Deuterium Cyanide in the 130-180 nm Range," T. Nagata, T. Kondow, Y. Ozaki, and K. Kuchitsu, Chem. Phys. *57*, 45 (1981),

"Absorption Spectra of the Outermost 5d Core-levels in Lead and Bismuth," A. Ejiri, F. Sugawara, H. Onuki, M. Hirano, and T. Yao, J. Phys. Soc. Japan *50*, 45 (1981),

"Fluorescent Emission and Scattering Spectra of Lithium Fluoride by Using Synchrotron Radiation," O. Aita, K. Tsutsumi, K. Ichikawa, M. Kamada, M. Okusawa, H. Nakamura, and T. Watanabe, Phys. Rev. B *23*, 23 (1981),

"Piezoreflectance of K^+ 3p Core Excitons in KBr," H. Fukutani, A. Yamada, T. Koide, A. Misu, and G. Kuwabara, J. Phys. Soc. Japan *50*, 1587 (1981),

"Time Resolved Investigation of the Deexcitation of Xenon Excimer by SF_6 and N_2 Excited with Synchrotron Radiation," Y. Hatano, M. Ohno, N. Kouchi, A. Yokoyama, G. Isoyama, H. Kitamura, and T. Sasaki, Chem. Phys. *84*, 454 (1981),

"Multiplet Structure of the Inner Core Absorption Spectra of $KMnF_3$ and $KCoF_3$ Measured by Synchrotron Radiation," S. Shin, S. Suga, H. Kanzaki, S. Shibuya, and T. Yamaguchi, Solid State Commun. *38*, 1281 (1981),

"Chlorine L Absorption Cross Section of Gaseous HCl and Cl," K. Ninomiya, E. Ishiguro, S. Iwata, A. Mikuni, and T. Sasaki, J. Phys. B: At. Mol. Phys. *14*, 1777 (1981),

"Final State Interaction of Inner Core Absorption Excitation in Transition Metal Halides," S. Shin, S. Suga, H. Kanzaki, S. Shibuya, and T. Yamaguchi, J. Phys. Soc. Japan *51*,(1982) in press,

"Reflectance Spectra of $ZnCr_2Se_4$ Spinel from 4 to 100 eV Measurement with Synchrotron Radiation: Band Structure Covalency and Final State Interactions," S. Suga, S. Shin, K. Inoue, M. Taniguchi, I. Nakada, S. Shibuya, and T. Yamaguchi, submitted to Phys. Rev. B,

"Inner Core Excitation of Transition Metal Compounds : I. p-XPS," T. Yamaguchi, S. Shibuya, and S. Sugano, submitted to J. Phys. C,

"Inner Core Spectra of Transition-Metal Compounds: II. p-d Absorption Spectra," T. Yamaguchi, S. Shibuya, S. Suga, and S. Shin, submitted to J. Phys. C,

"Reflectance Spectrum of Lithium Hydride at the Li K-Absorption Edge," T. Miki, M. Ikeya, Y. Kondo, and H. Kanzaki, Solid State Commun. *39*, 647 (1981),

"Relaxation Process from Higher Excited States of Self-trapped Excitons in Condensed Neon," T. Suemoto and H. Kanzaki, J. Phys. Soc. Japan *50*, 3664 (1981).

- Activity Report of SRL-ISSP

ISSP issues a publication, *Activity Report of Synchrotron Radiation Laboratory*, annually. The 1981 Activity Report is the fourth one issued and includes three to five page reports on various activities of the laboratory. The titles of the reports for 1981 along with authors and their affiliations (notice the diversity of institutions using the facilities) follow:

"Exposure Characteristics of Electron Beam Resists for Synchrotron X-ray Lithography", T. Kimura, K. Mochiji, H. Obayashi, M. Migitaka, Central Research Laboratory, Hitachi; A. Mikuni and H. Kanzaki, ISSP,

"Core-level Reflectance Spectroscopy of Ge by Means of Synchrotron Radiation," M. Taniguchi, S. Suga, S. Shin, K. Inoue, M. Seki, and H. Kanzaki, SRL-ISSP,

"Vacuum Ultraviolet Reflectance Spectra and Band Structures of Pyrites (FeS_2, CoS_2 and NiS_2) Measured with Synchrotron Radiation," S. Suga, K. Inoue, M. Taniguchi, S. Shin, M. Seki, SRL-ISSP; and K. Sato, Broadcasting Science Research Laboratories of Nippon Hoso Kyokai,

"Piezoreflectivity Spectra of KBr and KCl Measured with Synchrotron Radiation," A. Yamada, H. Fukutani, S. Nishimoto, and A. Misu, Department of Physics, University of Tokyo,

"Excitation Spectra of the Intrinsic Luminescence of Solid Neon and Argon," K. Inoue, H. Sakamoto, and H. Kanzaki, ISSP,

"VUV Spectra of $Y_3Al_5O_{12}$ Single Crystals," T. Tomiki, F. Fukudome, M. Kaminao, Department of Physics, University of the Ryukyus; and M. Seki, SRL-ISSP,

"An Attempt at Fluorescence Lifetime Measurements of Liquid Hydrocarbons Using the Pulsed Character of Synchrotron Radiation," N. Kouchi, K. Shinsaka, Y. Nakamura, M. Toriumi, H. Koizumi, T. Tezuka, N. Takahashi, M. Ukai, S. Yano, Y. Hatano, Department of Chemistry, Tokyo Institute of Technology; G. Isoyama, SRL-ISSP; and T. Sasaki, KEK,

"Time of Flight Measurements of Photodissociation of O_2^+," Y. Morioka, S. Aoyama, Y. Kageyama, T. Hayaishi, M. Nakamura, Institute of Physics, Tsukuba University; T. Hayaishi, Institute of Physical Technology, Tsukuba University; G. Isoyama, SRL-ISSP,

"Initial Stage of Sputtering in Silicon Oxide," T. Hattori, Y. Hisajima, H. Saito, T. Suzuki, Department of Electrical Engineering, Musashi Institute of Technology; H. Daimon and Y. Murata, ISSP,

"UPS and Yield Spectra of Low-spin FeS_2 in the Valence and 3p-core Excitation Region, S. Suga, S. Shin, M. Taniguchi, M. Seki, SRL-ISSP; S. Shibuya , ISSP; and T. Yamaguchi, Department of Applied Physics, Shizuoka University,

"Photoemission Spectra of $CuFeS_2$," M. Seki, S. Suga, M. Taniguchi, S. Shin, H. Daimon, SRL-ISSP; and K. Sato, Broadcasting Science Research Laboratories of Nippon Hoso Kyokai,

"Photoelectron Spectra of Ce, Pr, and Yb Metals," H. Ishii, T. Hanyu, H. Ohkuma, and S. Yamaguchi, Department of Physics, Tokyo Metropolitan University,

"4d-Core-level Shift for InSb (110) Cleaved Surface," M. Taniguchi, S. Suga, M. Seki, S. Shin, H. Kanzaki, SRL-ISSP; K. Kobayashi, Optoelectronics Joint Research Laboratory,

"Photoelectron Spectra of MnSi, FeSi, and CoSi," A. Kakizaki, T. Komatsubara, T. Ishii, Institute of Materials Science, Tsukuba Univerity; H. Sugawara, I. Nagakura, Gunma University; and Y. Ishikawa, Department of Physics, Tohoku University,

"Resonant Photoemission in Transition Metal Chlorides," A. Kakizaki, K. Sugeno, T. Ishii, Institute of Materials Science, Tsukuba University; H. Sugawara, I. Nagakura, Gunma University; S. Shin, SRL-ISSP,

"Extreme Ultraviolet Photoemission Spectra of Alpha-Manganese," H. Sugawara, I. Nagakura, Gunma University; A. Kakizaki and T. Ishii, Institute of Materials Science, Tsukuba University,

"Electronic Structure of Hydrogenated Amorphous Silicon-Carbon Alloys Studied by Photoelectron Spectroscopy Using Synchrotron Radiation I.," Y. Katayama, T. Shimada, Central Research Laboratory, Hitachi, Ltd.; L. I. Kobayashi, Optoelectronics Joint Research Laboratory; C. Jiang, H. Daimon and Y. Murata, ISSP,

"Photoelectron Study on the Surface Components of the 4f Levels in Yb Metal," Y. Takakuwa, S. Takahashi, S. Suzuki, S. Kono, T. Yokotsuka, T. Takahashi, and T. Sagawa, Department of Physics, Tohoku University,

"X-ray Absorption Spectra of Uranium by Synchrotron Radiation," H. Adachi, Hyogo University of Teacher Education; K. Fujima, K. Taniguchi, M. Sano, H. Anada, H. Takeuchi, Y. Hinatsu, C. Miyake, S. Imoto and H. Yamatera,

"Lethal Damage of Bacteriophase T1 by Irradiation in Dry State with Monochromatic Synchrotron Radiation," H. Maezawa, Department of Radiology, Tokai University; and K. Suzuki, Department of Molecular Biology, Tokai University,

"Ultraviolet (150 nm-250 nm) Action Spectra for Killing and Mutagenesis of *Bacillus subtili* Spores Obtained with Synchrotron Orbital Radiation," N. Munakata, National Cancer Center Research Institute,

"Induction of Prophages in *Bacillus subtilis* Spores by Synchrotron Radiation UV Irradiation: Dependency on the Wavelength," T. Kada and Y. Sadaie, Department of Induced Mutation, National Institute of Genetics,

"Wavelength Dependence of Inactivation and Membrane Damage of Yeast Cells by Monochromatic Ultraviolet Radiation in a Range from 145 to 254 nm," T. Ito, *Institute of Physics, University of Tokyo*; K. Hieda, Biophysics Laboratory, Rikkyo University; and K. Kobayashi, Biological Science, Tsukuba University,

"An Enzymatic Detection of Single-strand DNA Breaks Induced by Monochromatic (160 nm) Synchrotron Radiation in Dry Barley Nucleus," H. Yamaguchi and A. Tatara, Laboratory of Radiation Genetics and Chemical Mutagenesis, University of Tokyo,

"Irradiation of HeLa Cells by Monochromatic Ultraviolet Radiation Using Electron Storage Ring," K. Shinohara, Medical School, Kobe University; T. Ito, A. Ito, University of Tokyo; K. Hieda, Rikkyo University; and K. Kobayashi, Tsukuba University,

"Test of VUV Beam Position Monitor," T. Katsura, H. Nakagawa, and S. Shibata, KEK, and

"Study on an Injection Process of SOR-RING," S. Asoka, G. Isoyama, A. Mikuni, H. Nishimura, and Y. Miyahara, SRL-ISSP.

SUPER-SOR-RING-ISSP (SSOR-ISSP).

A design study of a new 1 GeV electron storage ring using an undulator for producing radiation one thousand times as bright as the SOR-RING in the vacuum ultraviolet and soft x-ray regions has been proceeding mainly with respect to the magnet and RF systems. This device will produce a useful wavelength as low as about 15 Å compared to 30 Å for the SOR-RING. This project is to be known as Super-SOR-RING-ISSP (SSOR-ISSP). A study meeting on SSOR-RING was held at ISSP in January of 1982. Some design values for this machine are given in Table II. If approved, this facility will belong to ISSP. It is this device which is justifying the addition of five people to the SRL-ISSP staff. No decision has been made as to location.

TSUKUBA ELECTROTECHNICAL LABORATORY LINAC-TSUKUBA ELECTRON RING FOR ACCELERATING AND STORAGE (TELL-TERAS)

A five million dollar construction budget for an electron linear accelerator and storage ring at ETL was approved about two and a half years ago. The justifications for the facility included the establishment of high energy radiation standards and the study of dosimetry. As mentioned earlier, the installation is now providing synchrotron radiation. The facility will be used primarily by ETL researchers. However, it is not a closed laboratory and is open to universities, industry, and other institutions. (Y. Watanabe of the Department of Mathematics and Physics of the National Defense Academy was working on the machine on the day of my visit.) The complex constitutes the Radiation Section of the Quantum Technology Division of ETL. The section, which built a 25 MeV betatron about 25 years ago, is headed by T. Tomimasu.

The linear accelerator is known as TELL, the Tsukuba Electrotechnical Laboratory Linac. The storage ring is known as TERAS, the Tsukuba Electron Ring for Accelerating and Storage. Terasu is also a Japanese verb meaning "to illuminate," and Amaterasu (ama is Japanese for sky) is the name of the sun goddess from whom all Japanese emperors are descended. The combined facility is known as TELL-TERAS.

TELL, which was constructed in six months, consists of a 500 MeV electron linear accelerator which is used, among other purposes, to inject 300 MeV electrons into TERAS. A celebration for the completion of the beam accelerator was held on December 22, 1980. At present, there are seven klystrons (manufactured by Toshiba in cooperation with ETL) which supply 175 MW total RF power at 2856 MHz. The efficiency of these klystrons is as high as 50 percent. Tomimasu stated that this is the highest klystron efficiency in the world for this power range and allows the device to operate with about 70 percent of the power consumption of an ordinary electron linear accelerator. There are four beam lines from TELL that can be used simultaneously in addition to the beam line supplying TERAS. One of these beam lines is to be used for low energy (93 MeV) experiments, and another to be used to inject 208 MeV electrons into a proposed 250 MeV storage ring. (Construction of this 250 MeV storage ring is the next project to be undertaken.) The other two beam lines from TELL will provide electrons at around 500 MeV and one of these will be used to produce pions for physical experiments and for pion dose measurements. The pion channel is being prepared and will be completed in 1983. The fourth beam line will be used to study inner shell ionization of elements by 350 MeV electrons.

Electrons to be injected into TERAS are deflected about five degrees by a pulsed coil and then bent by a magnet located in the beam transport system (about 40 m length). Four quadrupole lenses are used in the beam transport line for focusing. (The beam optics is difficult for this long length and there is a plan to try to reduce this distance to only two or three meters. In that case TELL would not be able to be used for any other purpose but injection.) The accelerating sections are of the linearly tapered iris type. This design is now also being used at KEK. (TELL is also being operated for high energy spectro-dosimetric experiments.)

TERAS whose properties are shown in Table III was completed in only one and a half years. Electrons are injected into the ring at the rate of $1\frac{2}{16}$ Hz. Successful injection of electrons into the storage ring occurred on August 26, 1981 and on October 7, 1981 the first storage of electrons was achieved. Three beam lines have been set up in connection with TERAS. One is used for calibrating soft x-ray standards, one is being used in conjunction with monochromators to study materials and the third is used to show sightseeing visitors what synchrotron radiation looks like. A fourth beam line will be used for LSI lithography.

I was present at an injection of electrons into the storage ring. The position of the electron beam with respect to the cross sectional area of the storage ring is monitored by a TV camera detecting the light emitted from a 50 micron thick aluminum film through which the electron beam passes. In July 1982 it took forty minutes to obtain 100 mA of stored current; the time depends on the vacuum and fine adjustments in the injection beam transportation system. The vacuum is generally less than 3×10^{-10} Torr but at the time of my visit there was a leak in the second beam line connection and the vacuum was 2×10^{-9} Torr. At this pressure repeated injection and loss resulted in a current of only 20 mA. The machine is designed to store 100 mA of electron current at 600 MeV.

The laboratory staff consists of seven people, six of which are permanent. This year almost all of the time has been spent on improving the quality of the existing 600 MeV storage ring.

- KEK-Photon Factory (KEK-PF)

The construction of the "Photon Factory" at Tsukuba for synchrotron radiation research was approved in the FY 1978 budget. The construction is well advanced and operation of the synchrotron radiation facility was scheduled to start in the summer of 1982

and as has already been stated, synchrotron radiation is now being produced. KEK-PF consists of a 400 m-long 2.5 GeV electron linear accelerator and a 2.5 GeV electron storage ring which will supply photons with a useful maximum energy about one hundred times greater than those emitted by the SOR-RING. (When I visited the storage ring I walked on a red carpet which had been put in place for President Mitterand who had visited the facility a few weeks before. A break in the storage ring was temporarily made so that President Mitterand would not have to bend down during his tour. Prime Minister Suzuki had visited the facility just a few days before my visit.) The linear accelerator has five sections with 500 MeV added to the electron energy in each section. It has forty two 30 MW Mitsubishi klystrons. The normal power for each klystron is 22 MW with 8 MW for reserve power. (The linear accelerator is also used as an injector for an 8 GeV electron accumulator, now under construction. These 8 GeV electrons will be injected into a 30 GeV electron collision ring. Thus the linear accelerator will have multiple uses.) It is also possible to remove electrons from the linear accelerator at 0.5 GeV and 1.0 GeV. There is a proposal to construct another storage ring for the vacuum ultraviolet for the 1.0 GeV electrons and a design study is underway. Plans are being made to install undulators in both the 2.5 GeV and the (proposed) 1.0 GeV storage rings. Last year, an undulator with nineteen poles using SmOs and Fe as permanent magnet materials was tested at SRL-ISSP by Photon Factory personnel. (As already mentioned, undulators (and wiggler magnets) are magnetic devices which are superimposed on the magnetic field that keeps the electrons in orbit and undulators allow increases in the intensity of radiation locally for certain wavelengths without affecting the overall orbit of the electrons or the radiation emitted by the electrons in other parts of the storage ring.) The undulator test was so successful (the measurements and theory matched perfectly) that one will be installed in October 1982. An even bigger undulator than the one tested eventually is being planned.

At the time of my visit in May 1982, the then most recent test of the storage ring had resulted in an electron current of 6.2 mA at 2.5 GeV. (The design calls for 500 mA at 2.5 GeV.) This was attained without water cooling, baking, or ultrahigh vacuum (the base vacuum under which these results were obtained was 10^{-8} Torr which increased, under injection, to 10^{-6} Torr). With each increase in energy of the electron beam, new degassing occurs. A current of 100 mA at 1.7 GeV had been attained but with a very short lifetime. The ultrahigh vacuum, baking, and water cooling systems were to have been completed by June 1982.

The plans are to operate the machine from 9 a.m. to 10 p.m. All RF and magnet power is to be turned off during down time since there are not enough funds to have power on continuously. Injections are planned to start every Wednesday morning during June and July and were to be stopped on Friday night. Next year, it is expected that the machine will be operated in two week shifts. There is not enough manpower to do this at the present time. It is not envisaged to ever operate the machine in a 24 hour/day mode.

About twenty experimental apparatuses are under construction and about ten are nearly complete. In contrast to procedures in such countries as the United States, in Japan, the design of such equipment is carried out by a group which includes scientists and engineers from industry. Perhaps two or three discussion meetings are held among representatives from academia and industry as to what type of apparatus should be constructed and for what purpose. For example, the x-ray topography apparatus is being designed under the chairmanship of a person from the NHK (Nippon Hoso Kyokai, hoso = broadcast, kyokai = corporation) Laboratory. The first design was carried out by the Hitachi Central Research Laboratory. But, it is a cooperative venture and will be carried out by a group including workers from NHK, Hitachi, and universities.

It was expected that ten or twelve beam lines would have been completed by June or July 1982 and I saw a large number of beam lines in various states of development. Four beam lines were fairly well-developed at the time of my visit, Beam Lines 10 and 15 for x-rays and Beam Lines 11 and 12 for the vacuum ultraviolet. Each of these four beam lines are divided into stations and the wavelengths of the radiation to be available at the various stations are shown in Table IV. One station of Beam Line 10 is for x-rays for EXAFS (Extended x-ray Absorption Fine Structure.) Another x-ray station is for small angle x-ray scattering by biological fibers and protein molecules as well as by complicated and artificial crystals. This work will be carried out at one or two Angstroms. Beam Line 11 will be used for solid state physics. Beam Line 12 will be used for very high resolution work (10^{-6} or higher) for atoms and molecules. This will be used to make precise measurements of autoionization and Auger effects.

Table IV gives the present information on the KEK-PF. KEK-PF will be a powerful light source ranging from the ultraviolet region to hard x-rays of about 0.4 or 0.5 Å wavelength, whereas the SOR-RING at SRL-ISSP provides mainly soft x-rays and ultraviolet radiation.

Eight scientists and four technicians were recruited in April 1982 alone. About forty visiting scientists are actively involved in the project at the present time. Three hundred outside Japanese users of the facility have already been designated.

ULTRAVIOLET SYNCHROTRON ORBITAL RADIATION (UVSOR) FACILITY, INSTITUTE FOR MOLECULAR SCIENCE (IMS)

The Institute for Molecular Science (IMS), a national facility, was founded in 1975 and as already mentioned, it is located in Okazaki (population 250,000). Okazaki is 25 miles south east of Nagoya or 160 miles southwest of Tokyo. Since the foundation of IMS the construction of a synchrotron orbital radiation facility (UVSOR) with a 0.6 GeV electron storage ring had been repeatedly proposed for research in molecular science and related fields. The machine is now being constructed and is expected to be operating in 1984. The proposed facility will consist of a 15 MeV linear accelerator to inject electrons into a 0.6 GeV synchrotron whose electrons will be transferred and stored in the 0.6 GeV storage ring. The reason for using an electron synchrotron for the principal acceleration is to conserve space. The output of the storage ring will extend to somewhat shorter wavelengths than does SOR-RING, but will be much more intense. For example, at 20 Å UVSOR will provide about 20 times the intensity. This improvement decreases sharply with increasing wavelength until at about 1000 Å the improvement is about 10 percent. UVSOR will, of course, not reach as low useful wavelengths as KEK-PF. The Photon Factory will provide much greater intensities than UVSOR at all wavelengths.

There will be three buildings and they will eventually be connected. One building is for both the linear accelerator and the electron synchrotron, and this building has already been completed. The linear accelerator has been completed, installed, and has been tested. The electron synchrotron is now under construction. The electron synchrotron will be tested in conjunction with the linear accelerator sometime during the fall of 1982. The second building is for the storage ring. It is under construction and is about 50 percent complete. It will be completed in March 1983. A third building for experimental studied has been completed. Four vacuum monochromators have been constructed up to now and three more will be constructed during the present fiscal year.

The main research fields to be undertaken with UVSOR are:

- optical spectroscopy
- photoelectron spectroscopy
- photochemistry, and
- elementary chemical reactions.

Table V presents data on UVSOR.

ACKNOWLEDGEMENTS

I am indebted to Professor Y. Miyahara (SRL-ISSP), to Dr. T. Tomimasu of TELL-TERAS, and to Professor T. Sasaki (KEK-PF) for their hospitality during my visits and for providing information. Professors H. Kanzaki and K. Kimura (IMS) provided helpful information. I am especially indebted to Professor N. Onishi of the University of Tokyo who accompanied me on my visits and with whom I had many long and helpful discussions.

Table I

SOR-RING (SRL-ISSP)

Operating institution	The Institute for Solid State Physics, The University of Tokyo
Sponsor	Ministry of Education, Science and Culture (Mombusho)
Address	Synchrotron Radiation Laboratory Institute for Solid State Physics The University of Tokyo Midori-cho, Tanashi, Tokyo 188
Director	H. Kanzaki The Institute for Solid State Physics, The University of Tokyo 22-1, Roppongi 7-chome, Minato-ku, Tokyo 106
INJECTOR	1.3 GeV INS-ES (electrons are injected at 300 MeV)
SOR-RING	
Started operation	December 1974 (regular operation since 1976)
Energy and maximum current of stored electrons	308 MeV, 510 mA; 380 MeV, 350 mA (Maximum energy, 400 MeV)
Radius of electron orbits at bending magnets	1.10 m
Bending magnetic field strength	0.9 to 1.1 T
Number of bending magnets	8
Circumference	17.4 m
Resonance frequency of the RF cavity	120.83 MHz
Vacuum	8×10^{-11} Torr (unloaded)
Operating pressure	1×10^{-9} Torr
Beam lifetimes at 380 MeV at various currents (July 1981)	350 minutes at 100 mA; 220 minutes at 200 mA; 180 minutes at 300 mA; 120 minutes at 350 mA;
Beam Line Wavelengths	BL-1 300 to 3000 Å BL-1' 400 to 2000 Å BL-2 90 to 350 Å BL-3 40 to 1000 Å BL-4 30 to 400 Å BL-5 Free port, users bring their own monochromators

Table II

SUPER-SOR-RING (SSOR)

(SRL-ISSP)

Design Values

Energy of stored electrons	1.0 GeV
Average radius	17.76 m
Number of bending magnets	12
Bending radius of electron orbits at bending magnets	3.82 m
Circumference	111.6 m
Resonance frequency of RF Cavity	around 120 MHz
Lowest useful wavelength	15 Å

Table III

TELL-TERAS

(ETL)

Operating institution	Electrotechnical Laboratory
Government sponsor	Ministry of Industrial Trade and Industry (MITI)
Address	High Energy Radiation Section Quantum Technology Division Electrotechnical Laboratory 1-1-4 Umezono,Sakura-mura, Nihari-gun, Ibaraki Prefecture, 305
Director	T. Tomimasu
Started operation	October 1981
TELL	0 mA at 500 MeV; 220 mA at 300 MeV; 77 m electron linear accelerator
Number of klystrons	7
RF Frequency	2856 MHz
TERAS	
Energy of injected electrons	300 MeV
Energy of stored electrons	600 MeV (630 MeV maximum)
Stored electron current	100 mA (achieved on July 20, 1982)
Lifetime of stored electron beam	2 hours
Circumference	31.45 m
Magnetic field strength	1.05 T
Number of bending magnets	8
Radius of electron orbits at bending magnets	2 m
Critical wavelength	44.7 Å
Operating pressure	8×10^{-9} Torr
Useful spectral range	10 to 1000 Å
Resonance frequency of of RF cavity	162.1 MHz

Table IV

KEK-PF

Operating institution	KEK (National Laboratory for High Energy Physics)
Government sponsor	Ministry of Education, Science and Culture (Mombusho)
Location	Oho-Machi, Tsukuba-gun Ibaraki-ken
Director	K. Kohra
Operation	First photons produced March 1982; regular machine operation from June 1, 1982

LINAC INJECTOR

Length of accelerator	400 m
Energy	2.5 GeV
Operating Current	50 mA
Pulse duration	1.5 microsecond
Number of 30 MW klystrons (2856 MHZ)	42

STORAGE RING

Energy of stored electrons	2.5 GeV	
Current	500 mA (Goal); 200 mA (Realistically)	
Radius of electron orbits at bending magnets	1.38 m (with strong superconducting wiggler magnets with magnetic field of 6 T) to 8.66 m (with magnetic field of 1 T)	
Useful wavelengths at various beam line stations nearing completion	BL-10-1	0.5 to 2 Å
	BL-10-2	0.4 to 3 Å
	BL-10-3	0.7 to 3 Å
	BL-11-1	400 to 2000 Å
	BL-11-2	10 to 200 Å
	BL-11-3	4 to 50 Å
	BL-11-4	60 to 600 Å
	BL-12-1	400 to 2000 Å
	BL-12-2	300 to 2500 Å
	BL-12-3	5 to 50 Å
	BL-15-1	0.8 to 2.5 Å
	BL-15-2	Less than 3 Å
	BL-15-3	1 to 2 Å
	(The labelling of the stations is not that used by KEK)	
Lifetime	10 hours (Goal)	
Number of bending magnets	28	
Critical wavelength generated by bending magmets	2.98 Å	
Critical wavelength generated at wiggler magmet	0.5 Å	

Table V

	UVSOR
Operating institute	Institute for Molecular Science
Sponsor	Ministry of Education, Science and Culture (Mombusho)
Address	38 Nishigonaka, Myodaiji Okazaki, Aichi prefecture 444
Director	H. Inokuchi
Operation to start	1984

CHARACTERISTICS OF INJECTOR SYNCHROTRON

Electron energy	0.6 GeV
Radius of electron orbits at bending magnets	2.0 m
Current	50 mA
Circumference	25 m
Vacuum	1×10^{-7} Torr
RF frequency	90.226 MHz
Time for electron acceleration	0.3 to 1 second

STORAGE RING PARAMETERS

Energy of stored electrons	0.6 GeV
Current	500 mA
Radius of curvature of electron orbits at bending magnets	1.8 m
Magnetic field of bending magnets	0.909 T
Number of bending magnets	8
Lifetime at 500 mA	1 hour
Vacuum when beam is stored	about 1×10^{-9} Torr
Critical wavelength	56.9 Å

REPORT ON THE 2ND INTERNATIONAL SYMPOSIUM ON RADIATION PHYSICS, PENANG, MALAYSIA

John H. Hubbell

Participants from 21 countries presented 99 papers at the Second International Symposium on Radiation Physics (ISRP-2) held at the University of Science of Malaysia (USM) in Penang, 25-29 May 1982. This symposium, a sequel to ISRP-1 (Calcutta 1974), was cosponsored by the USM, the Committee on Science and Technology in Developing Countries (COSTED) and the Asian Physical Society (APSO), and received additional financial assistance from the International Center for Theoretical Physics (Trieste), the Commonwealth Foundation, the British Council, and several other organizations. The Symposium was opened by the Malaysian Minister of Science, Technology and Environment, the Honorable Datuk Amar Stephen Yong.

The program was divided into eight sessions which covered basic radiation physics data:

- radiation sources,
- radiation detectors,
- radiation transport,
- applications of radiation physics,
- radiation and environment,
- teaching radiation physics, and
- miscellaneous topics ranging from laser fusion to microwave medical applications.

In Session One on basic data, the invited papers included reviews of the current state of photon atom interaction cross section data 100 eV to 100 GeV by J. H. Hubbell (United States), of photon atom coherent scattering theory by R. H. Pratt (United States) and of x-ray attenuation coefficient semitheoretical fitting for CAT-scan and other fast retrieval requirements by D. F. Jackson (United Kingdom). The rich variety of contributed papers included such topics as double internal bremsstrahlung, also a novel "inelastic atomic photoeffect" by A. Ljubicic (Yugoslavia), inner bremsstrahlung spectra from second forbidden β-decay by H. Sanjeevaiah (India), electron thermalization in various gas mixtures by S. Kubota (Japan), radiation pulse transient dielectric response by W. W. Guo (United States), near threshold pair production screening effects by S. K. Sen Gupta (India) and assorted treatments of photon elastic and inelastic scattering by I. B. Whittingham (Australia), by N. C. Paul, S. N. Roy, B. Sanjeevaiah and by B. S. Sood (India), and by V. Lakshminarayana (Singapore).

In Session Two on sources, A. M. Ghose (Malaysia), principal organizer of ISRP-2 as well as ISRP-1, delivered an invited paper outlining a proposed method for producing monoenergetic (8-12 MeV) neutron beams using elastic scattering of 14 MeV (t-d) neutrons from a surface-of-revolution hydrogenous converter shaped for maximum efficiency. Contributed paper topics included neutron and x-ray pulsed plasma diagnostics by C. S. Wong (Malaysia), neutron and photon secondaries from light ions penetrating shielding by Y. Uwamino (Japan), a compact and intense neutron generator by B. H. Choi (South Korea) and cosmic ray sea level neutron spectra by S. R. Ganguly (India).

In Session Three on detectors, M. A. Gomaa (Egypt) presented an invited review of solid state nuclear track and TLD detectors, in which he made ingenious use of the viewgraph projector to display some of his carbonate plastic neutron detector samples. Contributed paper topics included optimization of Marinelli vessel counting by H. Chisaka (Japan), megarad polymer γ dosimetry by W. Chung (South Korea), industrial γ-ray

computerized tomography by W. B. Gilboy (United Kingdom), film badge variability by J. M.Al-Mudaires (Kuwait), synchrotron radiation dosimetry by M. Pelliccioni (Italy), NE-213 liquid scintillator response to protons by T. Vilaithong (Thailand), a microcomputer-based pulse height analyser system by W. B. Gilboy (United Kingdom), filter modification of scintillation detector efficiencies by A. Achmad (Malaysia), tissue dose from photonuclear reactions in high energy radiotherapy by M. A. Chaudhri (Australia), gamma and neutron lyoluminescence dosimetry by B. Mitra (India) and a jumping spark counter for large area imaging using nuclear track detectors by D. B. Isabelle (France).

In Session Four on radiation transport, T. Nakamura (Japan) gave an invited review of theoretical and experimental studies of neutron skyshine from accelerators and other nuclear facilities. Contributed paper topics included γ buildup factors, also bent ducts in shielding, by G. B. Bishop (United Kingdom), γ halo around a source in a scattering medium by J. Swarup (India; presented by P. K. Sarkar), neutron albedos from layered slabs by K. Shin (Japan), electron and photon transport calculations by S. N. Kaplanis (Greece), γ buildup factor moments-method calculations 0.02 to 10 MeV for ALARA application by G. Gouvras (Switzerland), Monte Carlo transport calculations using negatively correlated random numbers by P. K. Sarkar (India) and an analysis of an industrial Co-60 irradiation facility by H. O. Quaranta (Argentina; presented by J. H. Hubbell).

In Session Five on applications, C. S. Chong (Malaysia) presented R. Jervis' (Canada) invited review of neutron activation applied to resource development, particularly oil sands and derived synthetic crude, noting surprising concentrations of trace elements in some samples. Contributed paper topics spanned art, technology, and health, including nuclear method analysis of ancient Chinese bronze seals by L. S. Chuang (Hong Kong), Mn/Co ratio in Chinese blue and white porcelain, also elemental analysis of herbs and herb preparations by C. T. Yap (Singapore), activation analysis of Malaysian tektites by S. B. Aidid (Malaysia), tracer studies of harbor silting by E. N. Lee (Singapore), concrete strength vs. Co-60 γ attenuation by R. Rukmantara (Indonesia) and diseased liver XRF elemental analysis by M. A. Chaudhri (Australia).

Session Six on environmental radiation consisted of thirteen contributed papers and a lively round table discussion of the impact of nuclear facilities. Contributed paper topics included various power plant and fuel processing effluent monitoring techniques and results by H. Hayakawa and Y. Takashima (Japan), L. Dierkes (West Germany), S. J. Hu and E. S. Lam (Malaysia), P. Chittaporn and N. Rativanich (Thailand), and by G. Gouvras (Switzerland), radioactivity from the 1980 Chinese weapons test by N. Momoshima (Japan), radon in building materials by C. Samuelsson and A. Petersson (Sweden), natural water radioactivity by J. M. Al-Mudaires (Kuwait) and global radiation balance as related to areas of the earth covered by ice and by deserts, respectively, by J. Bahadur (India).

J. Rotblat (United Kingdom) chaired the environmental impact round table, comprised of P. K. Iyengar (India), D. B. Isabelle (France), M. A. Gomaa (Egypt), S. Shimizu (Japan), G. Dhanaragan (Malaysia) and N. Muslim (Malaysia). Iyengar recalled that we were born in a big bang nucleogenesis and quoted from Freeman Dyson: "The problem is not the dangers-but the lack of new ideas. Nuclear power has fallen into the hands of accountants." Isabelle listed nuclear facility hazards including transportation and possible accidents; also, in operating plutonium retreatment plants: "We must remember, there is a critical mass, not to exceed!" Gomaa parametrized radiation protection objectives in a cost benefit formula. Shimizu provided statistics on both infant and adult cancer mortality rates in high- and low-dose natural radiation areas in Japan which suggested a negative correlation, if any, between cancer rates and these relatively low-level ambient dose fields. Similarly, no statistically significant difference in cancer rates could be detected between populations near and far from Japanese nuclear power plants. Nevertheless,

according to Shimizu, the Japanese are understandably "very nervous" about nuclear hazards, and patronize coin slot devices which read out body and local environmental activity. Dhanaragan questioned whether developing nations can "enjoy the luxury of the nuclear option" with its potential disasters from human fallibility, particularly in tropical rain forest areas which have few radiation resistant species. Muslim described the just commissioned Malaysian Triga MK II one MW swimming pool type research reactor and the care taken in the stable site selection as well as in the health physics, ecology, waste management, and other environmental impact considerations. In his summarizing remarks, Rotblat mentioned the long half-lives of reactor material activities as compared with those of nuclear weapons products; hence, the worst possible disaster would be a bomb dropped on a reactor: "If we are going to have nuclear reactors we do not want a nuclear war!"

Session Seven on teaching of radiation physics opened with an invited paper by P. K. Iyengar (India) reviewing and listing radiation physics courses which should be provided in nuclear science and technology programs, including radiation processes, detection systems, biological effects, shielding calculations, criticality control and transport of radioactive materials. Contributed paper topics included "industrial physics" curricula by C. T. Yap (Singapore), radiation protection training programs by W. B. Gilboy (United Kingdom), student use of Cf-242 neutron sources by S. Sukiman (Malaysia) and undergraduate free standing radiation physics courses by K. H. Ng (Malaysia) and by H. Sanjeevaiah (India).

Session Eight (miscellaneous topics) offered an excellent invited update by C. G. Morgan (United Kingdom) on laser fusion developments, including use of phase conjugated light beams which do not diverge on reflection, but retrace their incident paths. The contributed paper topics included directional sensitivity of nuclear track detectors using pit image asymmetry by K. H. Ng (Malaysia), diagnostics and therapeutic uses of microwaves by P. S. Neelakantaswamy (Singapore), γ scattering in the area of, (a) measuring techniques by V. V. Rao (India) and, (b) teaching techniques by D. F. Jackson (United Kingdom), He-3 neutron spectrometer studies of deuterium in solids by K. H. Beimer (Sweden), a simple and rugged diagnostic x-ray dosimeter by I. C. Patel (Papua New Guinea) and, finally an error analysis of on-line gamma radiometric gauging of void fraction in water transport systems by J. A. Oyedele (Nigeria).

PLANS FOR AN INTERNATIONAL RADIATION PHYSICS SOCIETY

Following ISRP-1, interest had been expressed in forming an International Radiation Physics Society (IRPS) which could serve as the primary sponsor for further symposia in this interdisciplinary subject area on a more formal and regular basis. At a meeting on May 28, the ISRP-2 Technical Committee, expanded to include 14 attending participants from ten countries, elected a pro tem committee consisting of:

A. M. Ghose (Malaysia), Chairman
J. H. Hubbell (United States), Secretary
M. A. Gomaa (Egypt)
D. Isabelle (France)
P. K. Iyengar (India)
D. F. Jackson (United Kingdom)
A. Ljubicic (Yugoslavia)
N. Muslim (Malaysia)
T. Nakamura (Japan)
I. B. Whittingham (Australia)

to explore and to take the necessary actions to form such a society (IRPS).

The primary objective of the Society would be the global exchange and integration of scientific information pertaining to the interdisciplinary subject of radiation physics, with emphasis on:

- research, theoretical and experimental, in the field of radiation physics,
- investigations of the physical aspects of the interactions of radiation with living systems,
- education in radiation physics, and
- utilization of radiation for peaceful purposes.

The above IRPS pro tem committee will undertake the task of organizing the ISRP-3, tentatively planned to be held in Egypt in 1985. For further information on the organization of the Society, please contact John H. Hubbell, (Secretary) U. S. Department of Commerce, National Bureau of Standards, Washington, D.C., 20234.

THE 9TH INTERNATIONAL CRYOGENIC ENGINEERING CONFERENCE, THE INTERNATIONAL CRYOGENIC MATERIALS CONFERENCE (ICMC), AND RELATED LABORATORY VISITS

Donald U. Gubser, Harry I. McHenry, and Young B. Kim

The joint conference of ICEC9/ICMC was held at the Kobe International Conference Center, Port Island, Kobe on 11-14 May 1982. About 550 people attended; including 62 Americans, 75 Europeans, 34 from other countries including the USSR (11), and the balance from Japan. The technical program consisted of six plenary lectures and 350 papers presented at technical sessions. Typically, three to five technical sessions were held in parallel, but the conference was organized to permit specialists to attend a series of sessions with minimal conflicts.

Major topics discussed during the four day meeting covered most aspects of cryogenic technology. Superconducting wire development and properties, large-and small-scale applications of superconductivity, mechanical and thermal properties of material (metals and nonmetals), refrigeration, LNG transport, and medical applications were discussed thoroughly.

The meeting began with two plenary sessions on large-scale applications of superconductivity. The first presented by Y. Kyotani of the Japan National Railway (JNR) described the Japanese superconducting magnetic levitation (MAGLEV) train. This project began in 1970 with the goal of providing ground transportation of comparable speed to aircraft; namely, 500 km/hr. In 1979 a speed of 517 km/hr was achieved on a 7 km test tract using linear synchronous motor propulsion. Following this initial success, the project has moved to more advanced test and development phases including a newly designed tract and a coupled car test vehicle. By the summer of 1982 manned tests will begin. The weight of the MLU-001-1 test train is ten tons, has eight superconducting magnets and an on-board refrigerator. This project is funded at a level of $20 million a year. Future plans call for a 40 km tract for full-scale testing.

The second opening plenary talk was by C. C. Henning of the Lawrence Livermore National Laboratory (LLNL) on Magnetic Fusion Energy Research-mainly concentrating on the Mirror Fusion Test Facility at LLNL, but including discussion of the Large Coil Project (LCP) at Oak Ridge. Magnetic fusion continues to be one of the two large-scale applications of superconductivity still pursued in the U.S.A. (the other being high energy physics). The large size and high field requirements on these fusion magnets pushes the limits of technology. The required fields are only marginally attainable with NbTi; hence, sub-4.2 K cooling is being considered. Higher magnetic field wire-Nb_3Sn or V_3Ga-is an alternative choice to achieve the higher fields. Fabrication difficulties as well as brittleness of these wires create problems during magnet construction as well as during operation due to the high magnetic stresses. The stresses require considerable structural support which increases the complexity of the overall system design.

Since most large scale applications of superconductivity would benefit from improved, higher T_C, high H_{C2}, wire there were numerous papers reporting development of Nb_3Sn and V_3Ga wire with the prominence of effort being on Nb_3Sn. The bronze formation method has been adopted by commercial manufacturers of this wire and has been scaled up to produce large quantities of Nb_3Sn wire. Fusion energy and high energy physics (HEP) research have driven this development. The LCP program alone required 12 tons of Nb_3Sn conductor. The economics for producing Nb_3Sn in such large quantitites compare favorably with the more standard NbTi wire ($160/kg vs. $110/kg).

Although the wire can be made reproducibly, it is still not achieving its ultimate potential hence, many papers continue to report on exploratory studies of Nb_3Sn wires formed by the bronze technique. The plenary talk by M. Suenaga reviewed much of the research aimed at improving the properties of Nb_3Sn and V_3Ga wires. Such studies concentrated on alloyed wires to raise J_C and H_{C_2} and on detailed studies of grain size and its interrelation with fabrication processes and critical current properties.

Alternate methods of producing Nb_3Sn and V_3Ga wire such as powder metallurgy or *in situ* casting also received considerable attention. Significant metallurgical problems have arisen in these methods such that large-scale viability is still questionable; however, the prospects of improved strain properties in these "discontinuous filament" wires is significantly exciting as to warrent continued activity in these areas.

The other major large-scale application of superconductivity in the U.S.A. is in high energy physics (HEP) and the biggest effort is at the Fermi National Accelerator Laboratory. W. B. Fowler reported on developments at the Fermi Laboratory in a plenary session. By the end of this year, 1982, construction of the components for the energy doubler proton accelerator ring will be completed. When completed the facility will have used enough NbTi superconducting wire to circle the globe. Approximately 770 dipole magnets and 200 quadrupole magnets will permit protons to be accelerated to 1 Tev. The talk concentrated on the refrigeration system which consists of a 4000 ℓ/hr helium liquifier, a distribution system for liquid helium and nitrogen and 24 satellite 1000 watt refrigerators located around the six kilometer circumference of the accelerator ring. Performance tests on the cryogenic system were reported.

Refrigeration itself was a major topic of the conference with considerable discussion of large-scale liquifiers, liquid helium and hydrogen transport, and heat exchange between components and the liquid or gas stream. In addition, there was a large interest in the smaller scale cryocoolers which produce continuous refrigeration in the range from 20 to 4.2 K. Such refrigerators are used for cryopumps, for cooling infrared detectors and parametric amplifiers, and for superconducting device applications such as SQUID magnetometers, Josephson junction computers, and superconducting resonance circuits. R. Radebaugh gave a good review of this field in his invited talk. Important improvements need to be obtained to lower the temperature limit (presently around 8 K) and to reduce the vibration and magnetic noise associated with cyclic refrigerators. Current research is concentrating on improving the low temperature regenerators used in Stirling, Gifford-McMahan, Solvay, and Vuillemier machines. Additional sessions on refrigeration dealt with cyclic demagnetization refrigerators using magnetic rare earth components ($Gd_3 Ga_5O_{12}$) to span the temperature range between 20 and 2 K and with dilution refrigerators to span the temperature range from 1 to 0.005 K.

Small scale applications dealt mainly with Josephson computer logic elements and circuits and with fabrication of reliable, reproducible junctions. Reproducibility of the junctions is of vital concern in the computer industry where multiple junctions must operate off the same control line. Related to this same problem is a desire to use refractory metal junctions instead of the Pb technology due to long-term reliability. Both T. A. Fulton of Bell Laboratories and H. Kroger of Sperry Research addressed these aspects in two invited talks. Kroger spoke of a new process, Selective Niobium Anodization Process (SNAP) which due to its inherent cleanliness offers advantages for multiple junction fabrication using niobium.

Returning to large scale applications of superconductivity, there were several sessions on superconducting generators. There is interest and research in many countries

on the development of superconducting generators for high efficiency generation of electricity. It is expected that field tests of experimental superconducting generators will begin in the 1980s with practical utilization in the 1990s. This may be the first industrial use of large scale superconductivity. Westinghouse and GE are developing this technology in the U.S.A.

Superconducting magnet technology--which is the heart of most large-scale superconductivity applications--received considerable discussion. Reports on cooling methods, temperature profiles, methods of detecting thermal and magnetic instabilities, strain effects, and ac losses were thoroughly discussed.

Report of an innovative cryogenic development was presented by H. Kataoka of the Research and Development Institute, Tokyo Gas Company where studies are underway on utilizing the "cold" energy available when LNG is revaporized for distribution. Potential uses of these vast cold reservoirs include;

- manufacture of liquid oxygen, nitrogen, or CO_2,
- refrigeration of warehouses,
- manufacture of frozen foods,
- direct power generation, and
- cold crushing.

The medical aspects of cryogenics were also discussed. J.E.C. Williams reported on the aspects of nuclear magnetic resonance (NMR), superconducting magnets used for diagnostic imaging. This medical tool is being extensively developed at the Massachusetts Institute of Technology in the U.S.A. and at the Technical Research Center in Finland. Cryosurgery was the topic of two of the talks. Although there are many advantages to cryosurgery, such as bloodless surgery and rapid healing, the techniques are not in common use due to a lack of simple, easily used instrumentation. Such instrumentation is being developed by G. Klipping of Germany (FRG) who showed slides of actual operations.

In the area of cryogenic materials, H. I. McHenry of the National Bureau of Standards discussed in a plenary session, the material selection considerations that govern the choice of structural alloys for cryogenic service. Three important cryogenic applications were described, the design requirements identified, and the properties of the preferred materials summarized. For superconducting magnets, high strength in heavy sections is important; nitrogen-strengthened austenitic stainless steels are the preferred alloys. For liquefied natural gas (LNG) tanks, economy consistent with safe performance is essential; high nickel steels are commonly used for land-based tanks and aluminum alloy 5083-0 for shipboard LNG tanks. For the space shuttle, strength-to-weight ratio and fabricability are the prime concern; aluminum alloy 2219-T87 is used.

The technical sessions on structural materials consisted of papers on the properties of currently used alloys and alloys under development. Most of the papers of both types were concerned with austenitic steels for superconducting magnets for fusion energy systems. Several papers dealt with alloys for LNG service, including aluminum alloy 5083, an austenitic manganese steel (18 Mn-5Cr) a ferritic manganese steel (6 Mn-0.4 Mo), and a matching filler wire for 9% Ni steel.

The currently used austenitic steels are primarily the nitrogen-strengthened Cr-Ni stainless steels. Papers were presented on alloying and magnetic field effects on flow strength; properties of plates, welds, and castings; and the design properties used for magnets made for the U.S. Department of Energy large coil project by Japan and Germany.

The austenitic steels under development were covered in papers covering the following alloys: Fe, 30Mn, 5-8Al, O-1C and 0-2Si; Fe, 10-20Mn, 15Cr, 5Mo; Fe, 25Mn, 5Cr, 1Ni; Fe, 40Mn, 10Cr; and Fe, 15-29Mn, 12-18Cr, 1-7Ni. Several of these alloys appear to be promising substitutes for the Cr-Ni stainless steels and warrant further research and development.

The last plenary session of the conference, discussed the cryogenic properties of nonmetallic materials. These materials have great utility as structural supports due to the small ratio of thermal conductivity to mechanical strength. Polymeric fiber composites can be "tailor made" by choosing appropriate fibers and matrix material to meet specific needs. Much development research remains to be done in this area.

POSTCONFERENCE LABORATORY VISITS OF DON LD U. GUBSER AND H.I. MCHENRY, RESPECTIVELY

Following the conference, I visited Mr. A. Iwata of Kawasaki Heavy Industries, Ltd. who arranged tours of Kawasaki, Osaka City University, and Kobe University of Mercantile Marine. Through these visits and discussions I gained much insight into Japanese research, life, and customs.

Kawasaki Heavy Industries, Ltd. is a large industry well-known in the U.S.A. for its motorcycle production. The Akashi Works, which I visited, is the home of the Kawasaki Technical Institute which was restructured and housed in new facilities in 1975. Over $40 million (2.1% of sales) are spent by the company on research and development. The main push of research is concerned with alternate energy processes, energy conservation, and environmental protection-all obviously of vital concern to Japan as alluded to earlier. The Institute is divided into eight laboratories. The group I visited was in the Applied Physics Research Laboratory, (section head, M. Yoshiwa). This group is specifically concerned with

- solar heating collectors used for heating, cooling, and desalination of sea water,
- studies of the cryogenic properties of gases, liquids, and nonmetals, and
- applications of superconducting magnets.

Current research is emphasizing thermal insulation materials used in LNG tanks and with cryogenic flow characteristics for large volume transport. The section has also been studying applications of superconductivity for ship propulsion and ocean current MHD electrical power generation. During the visit, I had discussions with M. Yoshima, A. Iwata, K. Haraguchi, and S. Nakagawa. I had the feeling from these discussions that each had a deep pride in both what they were doing and what Kawasaki Heavy Industries, Ltd was doing as a company. This is a very gratifying situation-and one which is not often felt in the U.S.A. Perhaps this company interest (which is reciprocated in Japan with numerous company benefits to the employee) is the reason for the high level of productivity in Japan.

At Osaka City University, I visited with Professors T. Kodama and T. Shigi. The Low Temperature Physics group is heavily involved with nuclear demagnetization cooling experiments. They have two demagnetization cryostats operational reaching temperatures to 0.2 mK. The cryostats are all constructed in-house (including the dilution refrigerator stage) and attest to the excellent quality of the craftsmen in the shops. As is commonplace in Japan, Osaka City University recovers all gaseous helium and reliquifies it. The group has been doing careful measurements on the molar volume dependence of nuclear magnetic ordering in solid ^{3}He as well as publishing several articles on ultra low temperature techniques. This group is one of several in Japan working below 1 mK and one of many possessing dilution refrigerator capabilities $T > 4$ mK. Clearly, there is considerable support for even the most basic cryogenic studies.

At the Kobe University of Mercantile Marine, I spoke with Professor Y. Saji and A. Iwata concerning the electromagnetic ship propulsion program. This propulsion technique works on the interaction between electric current and magnetic fields in sea water. The magnetic field is established with an on-board superconducting magnet and the electric current is generated between two high voltage electrodes on either side of the vessel. Such a propellerless propulsion system was first proposed in 1961 and early development occurred in the U.S.A. However, U.S.A. interest in this type of propulsion was abandoned in 1966. With the advent of high field superconducting magnets, Japan became interested in the project, and in 1976 tested the first model ship equipped with superconducting electromagnetic propulsion. Present research at Kobe University of Mercantile Marine is aimed at providing appropriate magnetic field screening of the fields in the sea water from the ship. Future plans call for the construction of a larger "inner magnetic field" type ship for performance tests. This type of propulsion system may be suitable for special types of marine applications. Near term targets are deep sea surveyors (where no shaft protrudes through the hull), ice breakers (where propellers are not damaged by floating ice), and dynamic positioning systems for floating platforms.

My visits in the Tokyo area were arranged by the Office of Naval Research, Far East, in Tokyo. The first laboratory I visited was the Electrotechnical Laboratory (ETL) located in new facilities at the Tsukuba Science City-a suburb of Tokyo. Dr. Kimura was my host. ETL is supported by the Ministry of International Trade and Industry (MITI), has a staff of 564 research scientists, and a budget of $19 million (1980). ETL is devoted to integrated basic and applied research in four broad areas;

- solid state physics and materials,
- information processing,
- energy and,
- standards and new technologies.

I visited a number of groups at ETL where cryogenic research was in progress.

The Low Temperature Physics section, headed by T. Ishiguro has a large effort on organic superconductivity. They have measured a $(TMTSF)_2ClO_4$ crystal with a transition temperature of 1 K and a transition width of less than 0.02 K. This remarkable achievement is still not thoroughly understood, but research is continuing. The abruptness of the transition could indicate a crystal quality better than that produced at any other laboratory and hence has important implications for future research in this area. I expect much international collaboration and much progress in the area of organic research from ETL.

The cryoelectronics and Josephson junction computer sections are also making significant technological advances. Dr. H. Hayakawa leads these groups and has been pioneering Josephson junction fabrication techniques involving double layer Nb/NbN-NbN/Nb junctions. This technique combines the improved junction quality of NbN interfaces with the smaller penetration depth of Nb.

The Refractory Metals section is studying ways of creating higher T_c materials both by sputtering (Nb_3Si and Nb_3Ge) techniques and by high pressure synthesis (Nb_3Si).

The Cryogenic Engineering section and Superconducting Applications section are conducting research on superconducting magnets for large-scale applications such as MHD and fusion power generation. Operation under pulsed conditions, ac losses, and different cooling schemes are all under study. One important aspect of this work is the detection of

acoustic signals prior to magnet quenches in large-scale magnets. Acoustic signal detection may prove to be an excellent means of quench prevention in large-scale systems.

Superconducting transmission lines remain an active area of research in the Energy Transport section and medical applications of superconducting SQUID devices are being studied in the Quantum Meteorology section.

I had the impression that almost every area of superconductivity research was being addressed at ETL-from basic materials to large-scale magnets and Josephson junctions for a variety of applications. Such a well-funded and well-rounded effort will undoubtedly lead to impressive technological advances in the cryogenic field.

The National Research Institute for Metals (NRIM) under the Ministry of Science and Technology, and located in new facilities at Tsukuba, has a scientific staff of 330 individuals and an annual budget of $18.3 million. About one-third of this budget is devoted to materials research with the vast majority of this devoted to materials exploited for energy saving and generation useage. Superconducting and cryogenic materials is one of two areas (the other being nuclear materials) being most heavily funded. The Superconductivity and Cryogenic Division, headed by T. Tachikawa, is divided into six groups:

- high T_C materials, where basic research on new types of superconducting materials is in progress (Nb_3Si),

- high-field superconductors, where superconducting wire development studies are in progress (Nb_3Sn and V_3Ga),

- superconductors for special applications, where stress effects and radiation effects are studied as a function of wire composite, type and fabrication method,

- new fabrication techniques, where *in situ* and rapid quench techniques for wire fabrication are studied,

- structural materials for cryogenic use, where studies of steels, titanium alloys, and welding techniques are performed at low temperatures, and

- magnetic materials for cryogenic applications, where rare-earth magnetic materials are developed for regenerative components in closed cycle helium refrigeration.

As compared to ETL, NRIM appears to have a stronger emphasis on materials development, about the same emphasis on basic research, less emphasis on magnet technology, and no research on Josephson junctions.

Harry I. McHenry's postconference laboratory visits covered the following institutions:

RESEARCH INSTITUTE FOR STRENGTH AND FRACTURE OF MATERIALS (RISFM)

The RISFM was established in 1964 to conduct interdisciplinary research on the fracture behavior of materials. It is currently undergoing a major change that may significantly alter its character during the next few years. Professor Takeo Yokobori, founder of the Institute, has recently retired, and the Institute is now under the direction of Professor Hideaki Takahashi. The Institute is likely to evolve from an effort centered

about Yokobori to a group effort involving fracture researchers from several departments of the Faculty of Engineering.

Professor Takahashi has moved from the Department of Metal Processing, to the Department of Engineering Science, to Professor and Head of the RISFM. He is the youngest professor at Tohoku University and appears to be a very aggressive and capable individual. His personal research interests are in the area of elastic-plastic fracture mechanics (EPFM) and acoustic emission monitoring. He has completely revamped the research program of the RIFSM, shifting from the fundamental approach of Yokobori to a diverse program of applied research. Emphasis is on EPFM, corrosion-related fracture studies, and fracture of rock. His well-equipped laboratory is overflowing the space available in the Engineering Science Department and will soon be moved to the RISFM laboratories.

The RISFM under Takahashi is likely to continue to be an important fracture mechanics laboratory. Its research program will have a stronger emphasis on areas under study at the U.S. Naval Research Laboratory (NRL) and Naval Ship Research and Development Center (NSRDC): ductile fracture using the J-integral and tearing modulus concepts, stress corrosion cracking, corrosion-enhanced fatigue crack growth, slow strain-rate testing, and acoustic emission monitoring.

NIPPON KOKAN KABUSHIKI KAISHA

Nippon Kokan (NKK) is a vertically-integrated company involved in steel production, engineering, construction, and shipbuilding. I visited the Technical Research Center in Kawasaki which supports all three industries. My visit was limited to the No. 3 Research Department, which is responsible for steel products development, fracture, and welding. My visit was arranged by Mr. Chiaki Ouchi, a supervisor in the Steel Products Laboratory, but Dr. Kazuo Horikawa, the former Research Director, was my principal host. The visit consisted of a seminar on EPFM research at National Bureau of Standards (NBS), discussions of steel requirements for arctic construction, and of new developments in steelmaking, and a tour of their fatigue, fracture, and structural testing laboratories.

Five topics of discussion were of considerable interest:

- Ship Steel for High Heat Input Welding

A new steel suitable for shipbuilding, NK-HIWEL, retains high toughness in the heat affected zone (HAZ) at temperatures down to -40°C even with heat inputs in excess of 1000 kJ/in such as obtained using the electroslag process. The improved HAZ toughness is attributed to a reduction of the nitrogen content of the steel to below 40 ppm, to an increase of aluminum to assure combination with the nitrogen (AlN precipitates), and to a small ($\leq$.01%) addition of titanium. In addition, the carbon equivalent of the steel is minimized by controlled rolling practices and the inclusion content is low due to low sulfur (<0.003) practice. Reducing soluble nitrogen is a new approach to improving HAZ toughness and may be more versatile than the titanium treated steels previously developed by Nippon Steel Company.

- On-line Accelerated Cooling (OLAC)

A new steelmaking practice, OLAC, replaces heat treatment with a controlled cooling of the as-rolled plate immediately upon completion of hot rolling. The process has been evaluated for ship plate that meets the requirements of HTS steel (a 50 ksi yield

strength steel). For HTS steel, OLAC processing improves toughness and weldability (reduced carbon equivalent) and reduces cost by eliminating heat treatment. It also improves the productivity of controlled rolling by permitting use of a higher finishing temperature. If licensed by U.S. steel producers, it would make available the advantages of controlled-rolling in plates up to 40 mm thick using available rolling mills. Currently, U.S. mills can only use control rolling for plates up to 20 mm in thickness because of the high force requirements associated with low finishing temperatures.

- High Manganese Austenitic Steel

For certain naval applications, a nonmagnetic shipbuilding steel would be of interest. The NM-I steel, (a 20 Mn-2Cr-.2C alloy) was developed for the Japan National Railway for use in the guideway for the magnetically levitated train. Compared with previous high Mn steels, NM-I has improved phase stability (does not become magnetic upon cold working), low thermal expansion coefficient (comparable to ferritic steels), and improved machinability and weldability. The strengths (minimum) at room temperature are 43 ksi yield and 85 ksi ultimate. The high degree of work hardening characteristic of Mn steels provides excellent energy absorption capacity.

- Ice Engineering

NKK has studied the ice forces acting on icebreaker hulls and offshore structures and the fracture toughness of sea ice. Tests are conducted at an experimental site in Hokkaido and in a cold room at the research center. Fracture toughness of sea ice is anisotropic, strain rate sensitive, and lower for sea ice (50 psi$\sqrt{\text{in}}$) than for pure ice (200 psi$\sqrt{\text{in}}$).

KOBE STEEL

Kobe Steel is a multifaceted company involved in steel production, engineering and construction, machinery, nonferrous metals (aluminum, copper, and titanium), and welding equipment and consumables. I visited the Mechanical Engineering Research Laboratory (MERL) and the Structural Engineering Laboratory (SEL). My host was Dr. Kazuo Ikeda, head of the MERL and formerly head of the SEL. The visit consisted of an overview of Kobe Steel's diverse activities, tour of both laboratories, and technical discussions relating to fracture mechanics (Ikeda's specialty).

Two topics of discussion were particularly interesting.

- Dynamic Crack Arrest Testing

Prior to joining Kobe Steel, Dr. Ikeda worked for the Ship Structure Division of the Ship Research Institute in Tokyo. In the mid-60s, Dr. Ikeda and Professor H. Kihara of the University of Tokyo developed wide plate test equipment and procedures for studying fracture initiation, propagation, and arrest. Since then, the steel industry has built similar test machines and adapted the test methods for routine evaluation of steel plates and weldments. The SEL tests specimens up to 1.5m-wide in a 6 x 10^6 lb-force capacity machine. The machine is horizontal permitting easy access for installing, instrumenting, and cooling these huge specimens. The SEL can conduct up to three of these tests in one day.

A dynamic crack arrest test is conducted on a duplex specimen; one side of the specimen is a brittle steel, the crack starter plate, and the other side of the specimen is

the steel under evaluation, the crack arrester plate. The specimen is loaded in tension to a specified stress level. A crack is initiated in the brittle plate (at Kobe, this is done by dropping a weight onto a wedge in the crack starter plate). If the material being evaluated performs successfully, the crack arrests when it enters that plate. The dynamic crack arrest tests offer two significant advantages over the explosion bulge tests used for the same purpose by the Navy:

- the specimen is amendable to fracture mechanics analysis,
- the specimen simulates the structural situation,
- the machine could be installed in a naval laboratory, thereby eliminating the nuisance of explosion bulge testing at an ever-dwindling number of remote test sites,
- the specimen is more suitable for research purposes because more observations are possible during the tests.

These advantages all increase the possibility of developing rational criteria for developing crack-arrest criteria for naval shipbuilding steels.

- Innovative use of Titanium for Offshore Oil Production

The Agency of Industrial Science and Technology is sponsoring a national R&D project entitled the "Subsea Production System." The objective of the project is to develop a system for producing oil from the ocean floor in deep water, without the use of either divers or guidelines. Kobe's contribution to the project is a completion riser and reentry system, which is basically an independently (of the surface) maneuverable pipeline that connects the wellhead to the floating platform at sea level. The bottom section of the riser is made of titanium, primarily because the low Young's modulus and high yield strength of titanium lets the bottom section act as a flexible link. The excellent corrosion resistance and good fatigue resistance also favor the use of titanium.

THE SEA IN OUR FUTURE: JAPAN MARINE SCIENCE AND TECHNOLOGY CENTER

Michael J. Koczak

INTRODUCTION

In 1971, with the approval of the 65th parliament, the Japan Marine Science Technology Center (JAMSTEC) was inaugurated. Japan, an island country with a relatively small land area of 380,000 Km^2, (Table 1) must rely heavily upon the sea for food, mineral, and energy resources. In terms of a "200 mile" marine economic zone it ranks sixth among world nations and derives benefits from the sea. As a consequence, JAMSTEC was established through the cooperative efforts of government, academia, and industry to promote and effectively develop marine science and technology. Located near Tokyo, in Yokosuka, it combines research, training, and technical information services. Isamu Yamashita and Shogo Kurachi are the President and Director General, respectively. Since 1971, the staff has grown from 30 to 128 persons, with a concommitant increase in the annual budget from Y700,000,000 to Y59,000,000,000 ($2,800,000 to $26,200,000: at $1=Y225) in 1982. The functions of the center are detailed in Table 2. In summary, JAMSTEC activities involve research and technology development, e.g., undersea and mineral resources exploration, (Table 3) personnel training and facility operation for the testing and performance evaluation of divers, equipment, as well as vessels.

RESEARCH ACTIVITIES OF JAMSTEC

During my visit to the center I met with Shogo Kurachi, Director General; Muneharu Saeki, Executive Director of Research and Development; and Shinichi Ishii, General Manager of the Marine Exploitation Technology Department. My hosts, Takeaki Miyazaki and Tadaaki Soejima, provided a thorough introduction to impressive and varied activities, which included, the high pressure test facility, a anechoic testing tank, the research submarine "Shinkai 2000" simulator; the towing basic utilized for the *Kaimei*, a wave power generator; as well as the undersea simulator and training facility.

The research efforts are divided into five general areas:

- deep sea survey technology,
- oceanic observation system,
- marine environment control and utilization,
- marine energy exploitation,
- manned undersea work research and development.

The showpiece of the facility is the "Shinkai 2000" a 2000 m deep manned submersible research vehicle, and her support or mother ship, *Natsushima*. The vessels are being utilized for undersea research and are currently undergoing sea trials. In addition, plans are being formulated for the "Shinkai 6000," based upon the experience from the sea design, construction, trials, and operation of the Shinkai 2000." At this point in time, it was not clear the level of scheduled planning given to the "Shinkai 6000," since it depends directly upon the achievements and performance of the "Shinkai 2000." The characteristics of the "Shinkai 2000" and *Natsushima* are provided in Table 4 and depicted in Figure 1. The purpose of the "Shinkai 2000" program is to facilitate research and provide for surveys in the areas of mineral resources, deepsea biology, oceanophysics, geophysics, and submarine structures. In summary, the ambitious project is well-underway and plans have been formulated for a 6000 meter research vehicle.

A second major research program involves the *Kaimei* project which employs a wave power generation system to generate energy utilizing efficient air turbines. Efforts are being directed toward an improved conversion efficiency from wave to air power as well as simplication and improvement of the turbine generation system. In operation, the *Kaimei*, an 80 m ship is moored perpendicular to a wave front. As the wave currents ebb and flow, a series of valves and generators schematically depicted in F'gure 2 convert the wave motion into electric power. Based upon early experiments, efforts are currently being pursued to improve the energy conversion efficiency and provide for electric power leveling[1, 2]. Performance results are being considered with regard to the relations of ship length, wave length, wave height, and power efficiency. The general program of experiments involve model testing in wave tanks at the JAMSTEC facility followed by open sea tests on the *Kaimei*.

In addition to these research projects, the facilities include an undersea training chamber, simulations a maximum diver depth of 500 m. They consist of three types of chambers:

- a wet chamber, 3.6 m in diameter and 6.2 m in height,
- a dry chamber 2.2 m in diameter and 7.5 m in length, and
- a spherical chamber 2.5 m in diameter.

A high pressure test vessel is available with a chamber size of 1.4 m and a length of 3 m, capable of cyclic and static pressurizations. The static pressure is comparable to a depth of 15,600 m, i.e., 15.6 kg/mm^2 (151 MPa, 22 ksi). Smaller pressure test chambers are also utilized for animal research to a depth of 1000 m, and a small high pressure facility is used for testing of equipment to depths of 7000 m. A 9 m anechoic tank, 9 m in width and 9 m in depth is designed for acoustic testing. In summary, JAMSTEC represents a significant research investment in Japan's future mineral and natural resources, the sea. For further information contact Japan Marine Science and Technology Center (JAMSTEC).

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The author gratefully acknowledges the tables and figures provided through the courtesy of JAMSTEC.

Table 1

MARINE ECONOMIC ZONES+

Rank	Country	Marine Economic Area (200 mile limit) ($10^3 km^2$)	Land Area ($10^3 km^2$)	Ratio of Marine Economic Area to Land Area
1	U.S.A.	7,620	9,360	0.8
2	Australia	7,010	7,690	0.9
3	Indonesia	5,410	1,900	2.9
4	New Zealand	4,830	270	17.9
5	Canada	4,700	9,980	0.5
6	Japan	4,510	380	11.9
7	U.S.S.R.	4,449	22,400	0.2

+Data Courtesy of JAMSTEC

Table 2

FUNCTIONS OF JAMSTEC

- Research and Technology
  - Deep ocean floor survey system
  - Ocean energy utilization
  - Manned undersea experiments
  - Joint industry and academic studies
- Training and Education
  - Marine diving techniques
  - Marine development seminars, e.g., oceanography
  - Special training courses, e.g., undersea welding, nondestructive evaluation, and open sea practical courses
- Facility Operation and Maintenance
  - Undersea simulation and training
  - High pressure test vessles
  - Underwater anechoic tank
- Technical Information Services
  - Collection of marine information
  - Dissemination of data and research results

Table 3+

VALUABLE MINERAL RESOURCES OF SEAWATER

Element	Concentration (ppm)	Estimated Weight (100 million ton)
Strontium	8.0	109,600
Lithium	0.17	2,330
Molybdenum	0.01	140
Uranium	0.003	40
Vanadium	0.002	30
Titanium	0.001	10

Table 4+

PHYSICAL AND OPERATIONAL FEATURES OF "SHINKAI 2000" AND *NATSUSHIMA*

"SHINKAI 2000"

Length:	9.3 m	Speed:	1 kt (cruise)
Breadth:	3.0 m		3 kt (max.)
Depth:	2.9 m	Crew:	2 Pilots
			1 Observer
Weight (dry):	24.5 tons	Life Support:	80 hrs for 3 men
Operating Depth:	2000 m	Payload	100 kg
Collapsing Depth:	3300 m		

NATSUSHIMA

Class:	NK	Gross Tonnage:	1500 tons
Length (Lpp):	60.0 m	Cruise Speed:	12 kt
Breadth (MLD):	13.0 m	Cruise Range:	8000 miles
Depth (MLD):	6.3 m	Accommodation:	30 (Ship's Crew)
			25 (Ops. Personnel)

INTEGRATED NAVIGATION SYSTEM

Surface Navigation:	NNSS/Loran C/Doppler Sonar/E-M Log and their Hybrid Navigation System
Submersible Tracking:	Long/Short/Super Short Baseline Acoustic Navigation System
Communication:	Underwater Telephone x2
Observation:	Side Scan Sonar/Echo Sounder/STDV/XBT

+Data courtesy of JAMSTEC

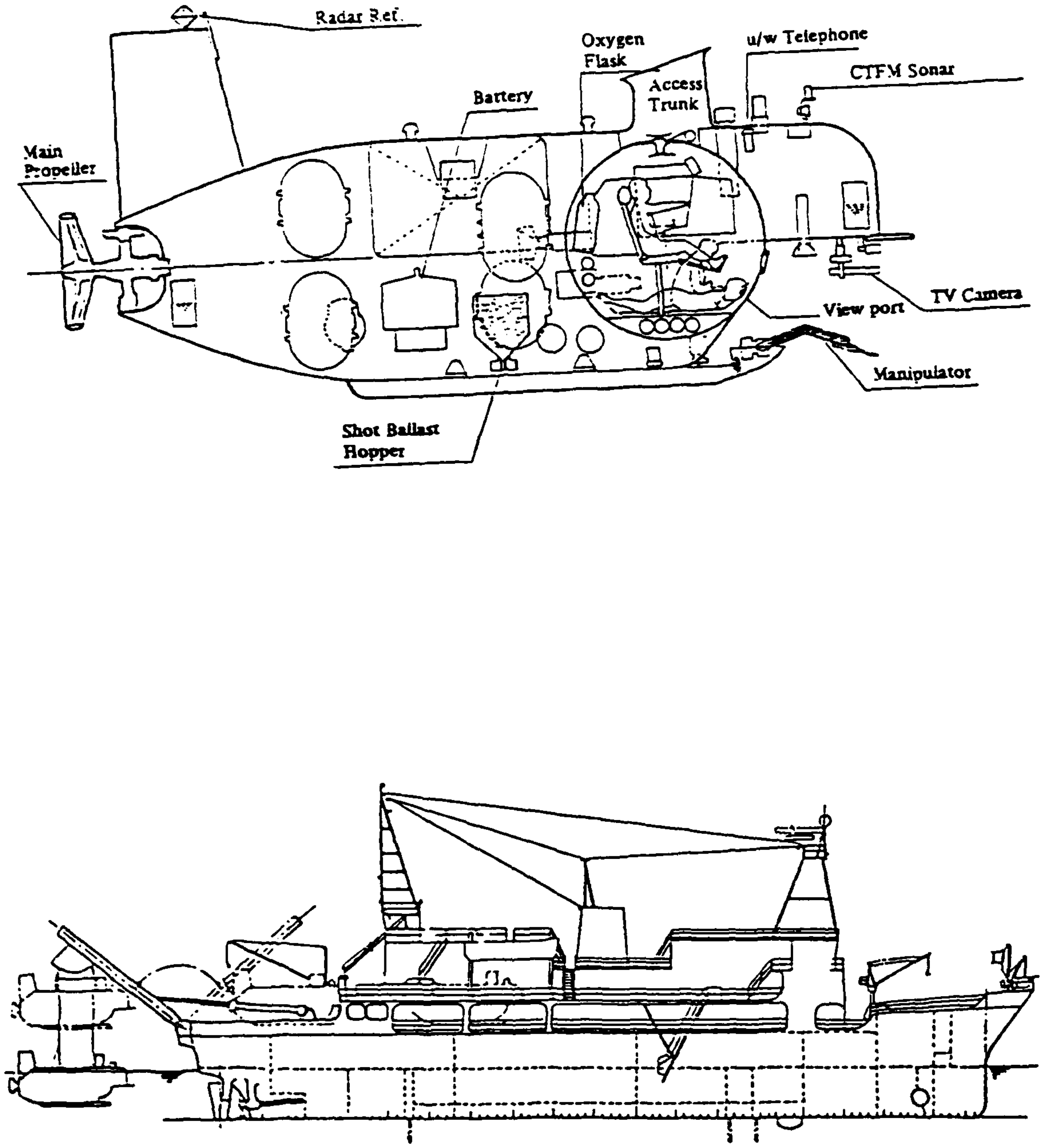

Figure 1. Schematic Diagram of "Shinkai 2000" and mothership *Natsushima* (courtesy of JAMSTEC).

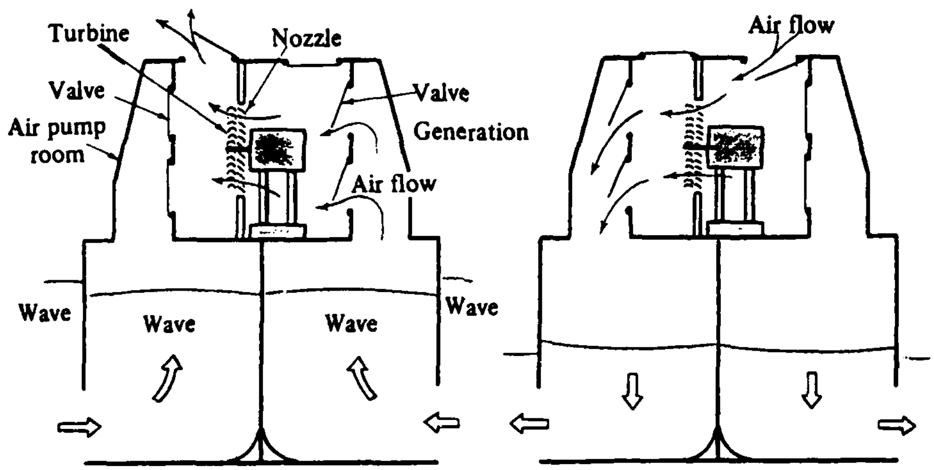

Figure 2. Schematic Diagram of Valve Mechanism and Power Generation on the *Kaimei* (with permission from JAMSTEC)

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2. "Reports and Future Plans for the *Kaimei* Project," Ishii, S., Miyazaki, T. *et al.* The Second International Symposium on Wave Energy Utilization, Tranheim, Norway, June 1982, pp 305-321.

POWDER PROCESSING IN THE FAR EAST

MITSUBISHI METAL RESEARCH INSTITUTE

Michael J. Koczak

INTRODUCTION

The first in a series of articles concerning metal and ceramic powder production and processing in the Far East, the author shall examine initially the activities in the metal powder industry in Japan, Korea, and China. In subsequent articles it is the author's intention to review the activities in the fine ceramics area, e.g. SiC, Si_3N_4,as well as fine filamentry ceramics fibers.

The Mitsubishi Metal Research Institute, 25 km north of Tokyo, located in Omiya City, Saitama, Japan, is the corporate research laboratory of the Mitsubishi Metal Corporation. Dr. Tadashi Hosoda is the Senior Managing Director at the institute as well as serving as the head of two of the research groups in heat and corrosion resistant alloys and powder metallurgy. The laboratory organization involves six research groups, as shown in the Appendix. The research institute has a staff of 260 people with 100 professional engineers and scientists. The analytic, processing mechanical and testing facilities located in Omiya, support and receive research funding from production facilities, e.g., Niigata, Okegawa, and Oii, of the Mitsubishi Metal Corporation. In addition, they provide engineering assistance to other members of the Mitsubishi group, for example, Mitsubishi Heavy Industries.

ACTIVITIES OF THE MITSUBISHI METAL RESEARCH INSTITUTE

The Mitsubishi Metal Research Institute was previously described in the ONR *Scientific Bulletin*, *2* (3), 24 (1977) by George Sandoz, who reviewed the general laboratory equipment and facilities. Although the research institute is located in a revered old building, the staff is pursuing very pertinent research topics. In addition, the institute appears to be upgrading its research equipment. The major analytic pieces of instrumentation had support staff using them and they were actively engaged in research analysis. New pieces of equipment included a JEOL JAMP-10 Auger electron analysis facility, a Conway, (ASEA) Pressure System, hot isostatic press (HIP) capable of producing small consolidated powder metallurgy and ceramic components. The laboratory press had a temperature range to ~2000°C and working pressures of ~200 MPa. The new small laboratory isostatic has been very actively utilized for over a one year period in the area of tool steels, nickel base superalloys, and titanium powders. In addition to the small laboratory hot isostatic press, (i.e., 50 mm in diameter, 100 mm in length, working chamber), two presses are utilized in separate plants which have chambers of 3.5 m in diameter and 2.0 m in length, and 4.5 m in diameter and 1.0 m in length. The production facilities are apparently used in the area of cemented carbides. A third notable addition included a laboratory-scale water atomization facilities primarily for the production of ferrous alloy steel powders. The melt capacity was 10 kg. It is anticipated to be used to promote the development and production of prototype corrosion and wear resistant ferrous powders. As a result of Mitsubishi's previously demonstrated capability in metal powder processing, they now have the ability to atomize, consolidate, and hot work a range of nonferrous and ferrous powders. It appears that they are assessing the full density, structural aluminum powder metallurgy area; however, the high power cost of aluminum refining and processing may make this market entry prohibitive.

TECHNICAL DISCUSSION

Technical discussions during the day centered primarily on powder processing of alloys and structure-property-processing relations. Yoshio Nishino, manager of the Powder Metallurgy Division served as my host and Dr. Tadashi Hosoda, Senior Managing Director actively participated in the discussions. As a general impression, Mitsubishi's metallurgy effort spans a wide range of alloy systems in both cast and wrought as well as powder processed systems. The powder activities involve conventional press and sinter components particularly in ferrous and copper base alloys. Tohru Kohno, formerly a visiting scientist at Drexel University, has developed Cu-Sn-MoS_2 bearing alloys and is currently investigating Fe-Cu-P-C alloys for improved dimensional control. A goal of their powder processing program is the understanding and control of growth and shrinkage of powder metallurgy materials in order to assure that variations in processing variables , e.g., temperature, atmosphere, density, chemistry, do not alter the dimensions of the final components. Yoshio Nishino described studies in Fe-Si-C alloys which combine the excellent wear characteristics of cast iron, but with improved machinability. Studies of high speed powder metallurgy tool steel powders were described, e.g., M-2 and T-15 alloys. In addition, higher alloy additions, e.g., V, are being considered for more wear resistant applications. The processing involved water atomization, cold compaction, and high temperature vacuum sintering in order to achieve densities of ~99% of theoretical.

In the area of nickel base superalloys, studies of Rene 95 and IN 100 powder processed alloys are being conducted. Investigations involved the examination of flow stresses as a function of forging temperature, i.e., 1000°C - 1250°C, and the influence of grain size on forging parameters. Tensile, creep, and stress-rupture studies examined the consolidated and forged properties as a function of hot isostatic pressing temperatures. Processing of a small turbine generator disc was also discussed. In this example, a powder metallurgy astroloy disc was diffusion bonded via hot isostatic pressing to an outer section of a nickel based cast and wrought alloy, 713C.

Titanium alloy processing is also being actively pursued with regard to cast and wrought as well as powder processed systems. Dr. Hosoda spoke proudly of the development of titanium alloy sheet from Ti-6Al-4V cast and wrought stock. Typical thicknesses ranged from 0.5 mm to 1.5 mm with widths and lengths of one meter. Powder rolling of titanium powders was also considered; however, these powder rolling studies are not currently being pursued. Titanium powder metallurgy parts are being produced from prealloyed powder as well as elemental titanium powder with master alloy additions. Unique metal composite structures were also shown, e.g., a composite bar consisting of titanium shell with a solid copper core which combines the properties of corrosion resistance and excellent thermal conductivity. In terms of powder processing, development, and production, Mitsubishi Metal Research Institute has a broad-based understanding in moderate to high density iron, titanium, and copper components as well as full density titanium, nickel, and wear-corrosion resistant ferrous base alloys.

The personnel at the Mitsubishi Metal Research Institute in the Powder Metallurgy Division include:

Dr. Tadashi Hosoda, Senior Managing Director
Yoshio Nishino, Manager, Powder Metallurgy Division
Tohru Kohno, Assistant Chief Researcher
Fumio Noda, Research Engineer
Koshiro Ueda, Research Engineer

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APPENDIX

MITSUBISHI METAL RESEARCH INSTITUTE

RESEARCH DIVISIONS

- Research and Environmental

    Mineral exploration
    Physical beneficiation
    Industrial waste treatment
    Environmental investigation

- Metallurgy

    Hydrometallurgy
    Pyrometallurgy
    Chlorine metallurgy

- Metallic Materials

    Nuclear reactor alloys
    Heat resistant alloys
    Corrosion resistant alloys
    Copper lead zinc alloys
    Surface treatment

- Powder Metallurgy

    Tool materials
    Machine and structural parts materials
    Friction materials
    Magnetic materials

- Chemical Materials

    Chemical instrumentation
    Fine chemistry
    Electronic materials

- Atomic Power

    Nuclear fuel engineering
    Nuclear chemical processing
    Nuclear fuel cycle engineering
    Nuclear ceramics

SUPPORT DIVISIONS

- Technical Services

    Analytic chemical evaluations
    Mechanical testing
    Materials science and microscopy
    Environmental testing
    Geological evaluation and testing
    Measurement services

- Administration

    Clerical section
    Maintenance and engineering section
    Clinic

- Planning

    Research management
    Library

VISITS TO SURFACE SCIENCE LABORATORIES IN JAPAN

H. W. Pickering

The author was University Invited Professor from May 1 to August 31, 1982 at The Institute for Solid State Physics of the University of Tokyo, while on sabbatical leave from the Pennsylvania State University. In this capacity he had the opportunity to visit several research laboratories within Japan in the areas of surface physics, electrode reactions and corrosion. Reports of some of these visits are presented below, as follows:

- Hokkaido University
- Government Industrial Research Institute, Chugoku
- The Research Institute for Iron, Steel and Other Metals, Tohoku University
- Osaka University
- Sumitomo Metals Central Research Laboratories
- Institute for Solid State Physics, The University of Tokyo

HOKKAIDO UNIVERSITY

Hokkaido University, Sapporo, Japan was founded over 100 years ago, and is one of the largest national universities in Japan. The Faculty of Engineering was established in 1924.

Professor N. Sato showed me the Electrochemistry Laboratory (in the Faculty of Engineering) which he heads. This research group, consisting of Associate Professor M. Seo, two assistants and typically about 10 graduate and undergraduate students, focuses its attention on corrosion mechanisms, and is one of the most active in Japan.

The main subjects of research in this laboratory are concerned with the surface electrochemistry of the iron group metals and alloys. The composition and structure of anodic oxide films are investigated by means of AES and XPS. Using these methods the depth composition profiles have been determined for passive films on iron base alloys which had formed in solutions of pH ranging from acid to base. The thickness of the anodic oxide films has been determined by *in situ* multiangle ellipso-reflectometry measurements. The redox reactions on anodic oxide films of tantalum are being investigated. Furthermore, a rotating ring-disc electrode technique is being applied for the study of the anodic dissolution of iron in acidic solutions. A gravimetric method using a microbalance is being applied for the study of the cathodic reduction of anodic oxide films on copper. The specific research subjects in the current year and the staff member in charge are as follows:

- Applied electrochemistry and corrosion science
  (Professor Sato)
- Surface analysis and physical chemistry of electrodes
  (Seo)
- Electrochemistry of precipitate films on metals
  (Sakashita)
- Optical study of surface oxide films on metals
  (Ohtsuka)
- Study of passive oxide films on stainless steels containing niobium
  (Kin)
- Study of electrode characteristics of anodic oxide films on tantalum
  (Sakon)

- Ellipsometry of anodic oxide films on titanium
  (Masuda)
- Study of surface oxide films on iron and nickel in strongly alkaline solutions
  (Sera)
- Reflectometry of passive films on iron and nickel
  (Azumi)
- Study of anodic dissolution and oxidation of iron by means of a rotating ring-disc electrode
  (Shintani)
- Study of anion adsorption in surface oxide films on metal electrodes
  (Nagao)
- Formation and physical properties of hydrous iron oxide films precipitated on copper alloy
  (Ono)
- Ion permeability of precipitate hydrous oxide films and crevice corrosion of metallic materials
  (Shimakura)
- Formation and physical properties of zinc phosphate films precipitated on iron
  (Nakagawa)
- Composition and structure of anodic oxide films on niobium
  (Baba)

A considerable effort has gone into the determination of the composition-depth-profiles of passive films and of the adjoining substrate alloy (usually iron alloys or stainless steels). The authors (Seo and Sato) believe that they have proven the existence of volume diffusion in the near surface region of the substrate alloy during oxidation at temperatures only modestly above room temperature. Fe-30Ni alloy specimens were oxidized at 433 to 373K in oxygen. The depth-composition profiles measured by Auger electron spectroscopy and argon ion sputter etching technique, reveal that a nickel-enriched zone is produced in the alloy side of the oxide-alloy interface. The thickness of the nickel-enriched zone increases from ~8 to ~22 nm with increasing oxidation time or temperature. Conditions were used for which no selective sputtering occurred. From the data the interdiffusion coefficient, D, in the alloy was estimated to be on the order of 10^{-15} cm^2 s^{-1} at 473 K which is more than 10 orders of magnitude higher than the value extrapolated from the lattice diffusion data obtained at high temperature. These investigators believe that the most likely explanation of the enhanced diffusivity is the so called divacancy enhanced lattice diffusion model in which vacancies are formed at the surface as an integral part of the selective oxidation of the iron. This is not a new model, having previously been presented to explain observations of volume diffusion during selective anodic dissolution at room temperature and selective vaporization at elevated temperatures. Its application to the more complicated selective oxidation process, in which a condensed phase (oxide) forms on the surface, is not completely clear.

Next year, Professor Sato will build a Raman spectroscopy system for application to corrosion studies. This is somewhat of a pioneering effort since the capabilities and usefulness of the technique for corrosion studies, though promising, are largely unknown.

Corrosion research is also performed in other groups within the materials science and engineering community, including the Analytical Chemistry Laboratory (Professor Dr. M. Nagayama) where recently the composition of anodically-formed barrier-type oxide films on aluminum in a neutral borate solution have been studied by x-ray photoelectron spectroscopy, and the High Temperature Metal Chemistry Laboratory (Professor Dr. K.

Nishida) where research on metal oxidation in dry gases at elevated temperatures is performed. Professor Nishida is well-known and active within the international community of scientists in the metal oxidation area. He is vice-chairman of the upcoming Third JIM International Symposium (JIMIS-3) on High Temperature Corrosion of Metals and Alloys, November 17-20, 1982, Susono City, Japan at the foot of Mt. Fuji. About 50 of the approximately 100 participants will be from countries other than Japan. Another activity in electrochemical research with a bearing on the hydrogen cracking problem is underway in the Research Institute for Catalysis. This work is under the able direction of Professor M. Enyo, who studied at the University of Pennsylvania in the laboratory of Professor J. O'M. Bockris. He has been studying the mechanism of hydrogen evolution on palladium and its relationship to hydrogen absorption by the Pd.

Thus, the visiting corrosion scientist will find a trip to Hokkaido University well worth the effort to reach this relatively distant part of Japan. In addition, Professor Dr. T. Takeyama's research using high voltage electron microscopy will be of interest. This laboratory, like most I saw, is particularly well-equipped. A new 1300 kV HVEM was installed this year. It is specially designed for studying irradiation damage in metals and alloys, being equipped with dual beam irradiation facilities which permit simultaneous irradiation with electrons and helium ions. An environmental cell is also available for *in situ* gas/metal experiments and the HVEM, itself, has been equipped with a high vacuum of about 10^{-6} Pa for this purpose. Professor Takeyama has in recent years focused his attention on irradiation effects in metals, with a particular emphasis on segregation and void formation in ferritic steels, and on corrosion related phenomena. He recently used the HVEM to observe initial cracking in hydrogen charged pure iron. However, he says that during the next few years the research effort on irradiation effects will increase, to some extent, at the expense of the corrosion effort.

The Research Institute for Catalysis, which was founded in 1943, is the oldest such institute in the world and is famous for the theory of chemical kinetics of Professor J. Horiuchi. About 25 staff members and 20 graduate students conduct research in the area of chemical kinetics of metal and semiconductor surfaces, electrochemical processes, surface phenomena in ultrahigh vacuum, field emission microscopy of adsorbates, and quantum mechanical rate theories of chemical reactions and adsorption phenomena.

In addition to Dr. Enyo at the Research Institute for Catalysis, I talked some with Dr. K. Ishizuka. He studies the migration of monolayer-thick adsorbates on metal surfaces using field emission microscopy. Recent results are for Si sputtered on Re. From measurement of the migration rate of the Si, he is determining the surface diffusivity of Si on Re in the temperature range, 100 to 220°C, for different crystallographic planes. Based on his results, including work function measurements, he concludes that some of the Si atoms are absorbed at these temperatures and reside within the lattice rather than as adatoms on the surface. Prior to these studies he investigated the effect of sulfur on the adsorption of hydrogen on molybdenum under field emission microscopy conditions which permitted a check on the cleanliness and the degree of contamination of the surface. The results indicate that atomic S on Mo blocks the sites available for H adsorption, whereas molecular sulfur does not.

GOVERNMENT INDUSTRIAL RESEARCH INSTITUTE, CHUGOKU

The Government Industrial Research Institute, Chugoku (GIRIC), located in Kure City of Hiroshima Prefecture along the coast of the Seto Inland Sea, is conducting an environment protection study of the sea using the world's largest hydraulic model. The Institute was founded in July 1971, as one of sixteen national laboratories of the Agency of

Industrial Science and Technology. The enormous and elaborately built Seto Inland Sea Hydraulic model is the main feature of the institute which as of 1980 employs 54 personnel. Its current Director-General is Dr. T. Hashimoto.

The Seto Inland Sea is squeezed by three major islands of Japan. It is shallow with an average depth of about 30 meters, sprinkled with numerous islands and connected with the outside oceans at two channels, called Kii and Bungo, and at the Kanmon strait. Movement of water in this sea is dominated by the tide but, in general, is rather quiescent. The surrounding land has attracted a large population and much industry, resulting in a large increase of effluent into the sea. This development, coupled with limited flushing by the sea, has brought about a serious water pollution problem. For this reason the Ministry of International Trade and Industry in 1970 decided to build a hydraulic model of the sea in order to study the means to abate further deterioration of water quality.

The Seto Inland Sea Hydraulic Model completed in 1973 reproduces the complex topography of the seabed in the scale of 1 to 2,000 and 1 to 159 in the horizontal and vertical directions, respectively. It covers an area of about 7,000 m^2 and contains more than 5,000 tons of water. Specifications call for the accuracy of the seabed topography to be within 2 mm. The model is equipped with three separate tide generating facilities which consist of oscillating weirs and recirculating pumps. These are operated at the central control room with the help of a 40 KB electronic computer which is also capable of recording output signals of the tidal gauges and other measuring devices onto a magnetic tape. The model includes more than seventy rivers into which a regulated flow of dye solution can be discharged.

The Institute has two departments, of which one, Machinery and Metals headed by Dr. T. Saito, has a Corrosion Engineering Division with Dr. K. Kudo in charge and a Production Engineering Division with Mr. H. Yokogawa in charge. Dr. Kudo was my host.

Corrosion Engineering Division

In the Corrosion Engineering Division, in addition to Dr. Kudo, there are five researchers and one research assistant. The laboratory is particularly well-equipped, especially so when one considers its short history. Major research facilities (all new in the last six years) include Auger electron spectroscopy, scanning electron microscopy, x-ray diffraction, plasma analysis for determination of alloy composition and carbon analysis equipment. Current research subjects are:

- corrosion and protection of metals in sea water
- corrosion and fouling of OTEC heat exhangers
- materials evaluation for hydrogen environment embrittlement
- electrochemical corrosion monitoring
- glass flakes pigmented paints for marine structures

K. Yokogawa, Chief Researcher, studies the hydrogen damage of an annealed Fe-2.25Cr-1Mo steel at elevated temperatures and constant loads in 9.91 MPa hydrogen. The creep rupture testing apparatus consists of a pressure vessel with an external electric furnace, a lever arm loading system, a counter pressure chamber for direct measure of the applied stress on the specimen using an external load cell, continuous recording of the elongation of the sample and three thermocouples directly attached to the specimen to measure the temperature. SEM is being used to analyze the fracture surface after testing at 723, 773, and 823K.

From the results Yokogawa believes that at the highest temperature (823 K) hydrogen attack (internal decarburization) occurs, based on a fracture surface which contains large voids characteristic of gas bubbles produced during hydrogen attack, and on a much decreased reduction of cross sectional area. This is a surprising result because operating specifications for this particular steel imply that it is immune to hydrogen attack in the operating temperature range (~450 to 850 K) of many industrial processes such as the liquefaction of coal and the hydrodesulfurization of crude oil. At all temperatures investigated the extent of secondary creep and the creep rupture time decrease and the secondary creep rate increase (in hydrogen) compared with results in argon. This degradation of the creep properties at all temperatures is due to another effect of hydrogen, and thought to be similar to that observed in creep rupture tests of Type 304 stainless steel, nickel base alloys, and iron-nickel alloys in hydrogen at elevated temperatures.

Dr. R. Nishimura, who joined the Institute about two years ago after receiving a Ph.D. under Professor N. Sato at Hokkaido University, is currently investigating the creep rupture behavior of austenitic stainless steels in heated acids at constant load. After rolling, samples are press cut out of the sheet and then annealed at 1100°C for 1 hr and water quenched.

Nishimura has observed that Types 304 and 316 stainless steels crack transgranularly at 80°C in 1M HCl at open circuit potential (10 to 43 kg mm^{-2}). Of these two stainless steels only 304 cracks 1N H_2SO_4 at 80°C, also transgranularly. At pH 4 or 5 no cracks occur in 10,000 hr for either solution.

The transgranular cracking originates at pits which form at the edges of the rolled sheet and penetrate into the sheet normal to the rolling direction. The pits are associated with slip steps. Pit density is higher at higher stress, consistent with pit formation at slip steps and also with Nishimura's suggestion that the cracking process is similar to the tunnel/slip-step model of cracking given in the literature originally for Cu-Au alloy and subsequently for austenitic stainless steels. In this model shear type ductile tearing occurs between neighboring pits, a feature that Nishimura also observes in his samples. The pits penetrating from opposite edges do not actually meet because overload and complete fracture occur first, as indicated by a dimpled fracture surface. Consistent with this overload condition, shallower pitting (larger dimpled fracture surface) is observed at higher applied stress.

Nishimura points out an interesting correlation in these data between log of the creep rate and time-to-failure, which could be quite meaningful but is not yet understood. In such a plot 316 is more creep resistant then 304 in both solutions and the creep resistance of both steels is lower in HCl than in H_2SO_4, as expected. In addition, however, one finds that these creep data all fall on a single line. The next tests will be run on a ferritic grade stainless steel (Type 430).

Nishimura is also studying the anodic dissolution behavior of Cu-10Ni alloy in 3% NaCl solution (pH 7), especially the tendency for selective dissolution of the Cu or Ni. Results are being obtained for the potential range 0.0 to 1.2 volts (S.H.E.). Thus far, data have been obtained on the concentrations of Cu and Ni in the 3% NaCl solution but not on their concentrations in the solid corrosion products which form on the Cu-Ni surface. A different behavior occurs above and below 0.7 V; below this potential Ni is enriched in the aqueous solution whereas above 0.7 V Cu is enriched in the solution.

Other studies in the Corrosion Engineering Division which were brought to my

attention but not described in detail include the development of effective coatings (nonmetallic and metallic) for protection in the splash zone, of submerged structures, in high-pressure hydrogen gas and for heat exchanger applications; evaluation of aluminum alloys in high-pressure hydrogen at various temperatures; and a study of the kinetics of growth and the structure of oxide layers which form on ferrous steels exposed to high temperature gases.

Production Engineering Division

Although I did not have the opportunity to talk with H. Yokogawa or others in the Production Engineering Division, the following description of their research activities was provided.

- Material Evaluation by Acoustic Emission. The objective of this research is to apply acoustic emission techniques to the prediction of fracture of offshore structures. The acoustic emission caused by material failure, cracking and fatigue is one of the promising approaches to nondestructive testing. Acoustic emission is also used to monitor the generation and propagation of fatigue cracks in welded joints.

- Measurement of Surface Damage by Exoelectron Emission. This research investigates the characteristics of exoelectron emission caused by material damage. Exoelectron emission decays as time goes on, and this feature is expected to be applied to fractography and to the surface analysis of materials.

- Availability of New Ceramic Tools in Machining. Newly developed cutting tools are being examined to find the optimum cutting conditions against hard-to-machine materials. Cutting mechanisms are also being investigated.

- Improvement of Strength and Workability of Stainless Steel in Plastic Forming. Strain induced transformation is being applied to deformation processes in order to improve the strength and workability of stainless steel under controlled temperature conditions.

THE RESEARCH INSTITUTE FOR IRON, STEEL AND OTHER METALS,
TOHOKU UNIVERSITY

The Research Institute for Iron, Steel and Other Metals is part of Tohoku University, Sendai, Japan. It has a staff of over 300 people studying primarily the physical metallurgy and mechanical properties of irons and steels, and has a major research activity in amorphous metals. This institute was visited in 1977, and an outline of its organization and research goals at that time are contained in the December 1977 *Scientific Monograph* by George Sandoz. My brief visit did not provide the opportunity to see much of this very large and impressive Institute. Discussions were held with members of the Institute working on the corrosion behavior of amorphous metals and on the segregation of P to grain boundaries in iron. The latter discussion was prompted by my lecture entitled, "An Atom Probe Study of P Segregation to Grain Boundaries and its Effect on the Anodic Dissolution Behavior of Steels."

My host was Professor K. Hashimoto, who is one of the leading international experts in the area of the corrosion behavior of amorphous metals. His current corrosion research is directed at answering questions, such as:

- What is the mechanism of the increased protective nature of passive films formed on certain amorphous iron alloys?

- What are the mechanisms of embrittlement (hydrogen cracking/stress corrosion cracking) of certain amorphous iron-base alloys when exposed to cathodic polarization in sulfuric acids or when immersed in acids containing chloride ions?

- What is the role of Mo in promoting the protective nature of passive films which form on amorphous Fe-Mo-P-C alloys?

- What is the role of P in this same regard?

- What is the mechanism by which Mo additions at the 1 or 2% level increase the corrosion (pitting and crevice corrosion) resistance of ferritic (crystalline) stainless steels in acid chloride solutions?

Hashimoto and co-workers have reported that amorphous alloys which contain Cr and P process extremely high corrosion resistance in acidic and neutral solutions with and without chloride ions. They point out that one characteristic of these films is their very high Cr content. Another is that phosphorus, which is present in large amounts in the amorphous alloys, accelerates the initial corrosion process and leads to rapid enrichment of trivalent chromium in the surface film. Since B and Si, in place of P and C in the amorphous alloy, do not yield similar results and are themselves incorporated in the passive film in place of Cr, it is concluded that both a high Cr content and a rapid initial corrosion process are important in promoting the protective nature of the passive layer. A third tactor, of no less importance, is the perfection of the passive layer which is reasoned to be more homogeneous because of the absence of crystalline defects in the amorphous alloy. X-ray photoelectron spectroscopy was used to measure the compositions of the passive layers, and provided much of the data leading to these conclusions.

Mo, at the 1 to 2% level in crystalline ferritic stainless steels, is known to give an improved resistance to pitting and crevice corrosion in acid chloride solutions. This beneficial effect of Mo, however, is not seen in the lower Cr steels or pure iron, unless one looks at the amorphous iron alloys. For example, passivation readily occurs even in the aggresive HCl aqueous solutions when Mo is added to Fe-P-C amorphous alloy. The composition of the passive film formed on the amorphous Fe-P-C-Mo alloy is found by XPS to be about the same as that formed on crystalline Fe and on low Cr-Fe alloys, mainly ferric oxy-hydroxide.

Thus, the amorphous Fe-Mo-P-C alloy does not pit in 1N HCl even though its passive film is comprised of ferric oxy-hydroxide. Yet, it is known from results on crystalline stainless steel and iron alloys that this film is less protective than the hydrated chromium oxy-hydroxide which forms on the stainless steels. These stainless steels, nevertheless, pit in 1N HCl. Hashimoto and co-workers point out that a logical conclusion is that crystalline defects existing in crystalline alloys are responsible for pitting. This conclusion runs contrary to results of some other investigators, and reopens the question of the importance of crystalline defects in pitting.

Embrittlement and cracking of some amorphous alloys have been found in bending and tensile tests after or during cathodic polarization in sulfuric acid, and during immersion or anodic polarization in acidic chloride solutions. In the potential region of cathodic polarization, susceptibility increases with increasing overpotential for the hydrogen evolution reaction, and the presence or absence of chloride ion does not seem to be a factor. In the more positive potential region of anodic polarization where chloride ion is required for cracking, the long standing question as to which, hydrogen or anodic metal dissolution, causes crack propagation needs to be resolved. Hashimoto and co-workers

suspect it is hydrogen cracking based on the results of room temperature aging experiments in which aging (following an embrittlement test) returns the sample to its pre-embrittled condition. This result has now been obtained also for anodic polarization. Hashimoto surmises that in the case of anodic polarization the local electrode potential at the crack tip must be much more negative, than that existing at the external surface, suitable for the reduction of hydrogen ions at the crack tips in spite of an unfavorable outer surface potential.

Mo increases the corrosion resistance of (crystalline) ferritic stainless steels because it is instrumental in forming a more perfect passive layer, though it is not itself contained in the layer. This conclusion by Hashimoto and co-workers is based on XPS results which show a higher water content in passive films formed on stainless steels which do not contain Mo as an alloying element. A higher water content is taken to mean a higher pore and defect density. It is supposed that a transient precurser film containing Mo, forms and establishes surface conditions more suitable for the formation of a homogeneous, more perfect passive layer.

Following my lecture Dr. K. Abiko contributed discussion on the segregation of phosphorus to grain boundaries in iron. His own research activities include:

- the segregation of P to grain boundaries in Fe and the effect of grain boundary structure, and
- the toughness and fracture mode of Fe-P alloys.

He and co-workers use Auger electron spectroscopy for measuring the grain boundary composition. The technique, which is well-known and generally used for grain boundary analysis, is applicable when the alloy is in the grain boundary embrittled condition, in which case the sample can be fractured *in situ* along the grain boundaries. Discussion centered on the upper limit of P in the grain boundaries of iron and on the recent use of atom-probe field ion microscopy for this purpose. Abiko and co-workers have some indirect evidence that phosphorus in the grain boundary is associated with iron as Fe_3P. Thus, they conclude that the upper limit of P in the grain boundary is 25 at.%. Their own Auger data show a leveling off of the P content as the temperature is lowered in qualitative agreement with this conclusion, although they can not obtain compositions from their peak-to-peak heights due to a lack of standards for calibration. On the other hand, our atom-probe measurements, which directly give composition, show the normal equilibrium temperature dependence of the P content at the grain boundaries, i.e., P content increases as temperature decreases with no plateau. A ~40 at.% P content (an upper value since it assumes all of the P is confined to a single atomic plane) was obtained at the lowest temperature of measurement (250°C).

OSAKA UNIVERSITY

Osaka University, which is the third largest national university of Japan, is one of the leading centers for the development and application of atom-probe field ion microscopy in Japan. Research using the atom-probe FIM is underway in two locations of the University:

- The Institute of Scientific and Industrial Research (ISIR) by Professor S. Nakamura who spent two years at the Pennsylvania State University as a postdoctoral fellow working for the late Professor E. W. Muller, the inventor of field emission and field ion microscopy, and

- The Department of Materials Science and Engineering by Professor S. Nenno and co-workers.

ISIR began in 1939 in Sakai. In 1968 the Institute moved into new buildings at its present site in Suita. During its over 40 years of existence, ISIR through its University affiliation has fostered the traditional basic and applied sciences and has been instrumental in the granting of doctoral degrees by the Faculties of Science and Technology. The Institute, headed by Dr. M. Koizumi, Director, consists of 21 research divisions, the Radiation Laboratory, the Research Center of High Pressure Synthesis, the Material Analysis Center, and several service sections. Each research division belongs to one of four departments, and normally is staffed by a full professor, an associate or assistant professor, and two research associates. The total staff numbers approximately 170, including 38 research assistants and 46 clerks and secretaries. Besides these permanent personnel, who are all government employees, about 25 research fellows and 80 graduate students conduct research in the Institute. Its annual budget, which is provided by the national government and in part by grants from public and private sources, is in excess of $5 million.

Professor Nakamura, Electronics Department, published the first field ion micrograph taken in Japan in 1961. It was of tungsten which, at that time, was one of the few materials (all were refractory metals) which could be successfully imaged with atomic-scale resolution. Since that time FIM has developed to the point that metals of all kinds and nonmetals including semiconductors can be studied. Professor Nakamura has also constructed a time-of-flight atom-probe FIM, another of Müller's inventions. This instrument, which is currently being used in the straight time-of-flight mode, is equipped with an energy focusing Poschenrieder lens for high resolution studies. Alignment of the energy focusing lens will be completed soon. A laser is used for evaporation of the atoms of the sample at reduced electrical fields. Use of the laser for modifying the structure of the sample (tip) is being explored. Preliminary results indicate that certain laser treatments produce grain boundaries in W metal tips. This is an exciting result since, if successful, will facilitate the use of the atom-probe FIM for studies of segregation to grain boundaries and to other structural features in Fe and other metals. In the author's talk to a combined audience of ISIR and the Department of Materials Science and Engineering the significant progress made on the development of the atom-probe FIM was mentioned. The metallurgist is particularly interested in the recent improvement in resolution of the atom-probe for studying problems in physical metallurgy, especially the very important problem of the nature of hydrogen in metals for which, until recently, atomic scale studies were not possible by this or other techniques.

Professor Nakamura is using the atom-probe FIM, along with other techniques for thin film studies such as ESCA, for analysis of lanthanum hexaboride and compound semiconductor whiskers, including GaP and GaAs. Preliminary results for LaB_6 show that B and La evaporate as a complex. Occasionally, individual B atoms are detected but the results are too preliminary to distinguish them from a field effect since the bias of the field is to cause larger molecules to dissociate into smaller ones. B does not seem to exist in clusters since only occasionally do two B atoms evaporate together, i.e., during the same 15 to 20 ns voltage pulse, and then they usually have different charges.

There are also some exciting energy loss experiments using inelastic low energy electron diffraction (ILEED) underway in Nakamura's group which are the full-time activity of Dr. H. Iwasaki. ILEED measurements are being performed on Si(100)-2x1 surfaces (surface cleanliness is verified by Auger analysis) in order to investigate the diffraction effect on inelastic scattering related to surface and bulk plasmon excitations. Progress is being made on explaining the relation between the elastic and inelastic I-V curves.

In the Department of Materials Science and Engineering Professor Nenno, Dr. M.

Yamamoto, who did atom-probe FIM research for two years with Professor D. N. Seidman, Cornell University, and co-workers are using the FIM for investigating phenomena in physical metallurgy. Ordering reactions are currently being studied in the Ni-Mo and Ni-W alloy systems. Recently, published work appeared for Ni_4Mo alloy (T. Kingetsu, M. Yamamoto and S. Nenno, Surface Sci., *103*, 13 (1981); *ibid.*, Jpn. J. Appl. Phys., *20*, 2037 (1981)) and for Ni-16.6 at.% W alloy (T. Kingetsu, M. Yamamoto, S. Nenno and H. Fukura, Jpn. J. Appl. Phys., *20*, 1407 (1981)).

Dr. T. Shibata, who distinguished himself as a young scientist in the corrosion area while at Hokkaido University, has just joined Osaka University and will contribute to the already strong metallurgy research activity. He has published extensively on the corrosion behavior of austenitic stainless steels, in particular on stress corrosion cracking, pitting and passivity breakdown.

SUMITOMO METALS CENTRAL RESEARCH LABORATORIES

The organizational development of the research laboratories of Sumitomo Metal Industries Ltd. is given in the report of G. Sandoz which appeared in the December 1977 *Scientific Monograph*. My recent (brief) visit was largely confined to the Chemical Metallurgy Laboratory under Dr. T. Moroishi, Chief, who has a staff of about 40 people, half of whom have advanced degrees, among them six with the Ph.D., of the Central Research Laboratories in Amagasaki. Discussions centered on their research in the corrosion area, as well as on points raised in two talks given by the author, entitled "Effect of H_2S and Cl^- ion in Aqueous Solutions on Hydrogen Absorption by Iron" and "The Limiting Electrode Potential in Pits and Cracks During Corrosion of Metals."

The Chemical Metallurgy Laboratory is organized into four groups.

- Materials for Chemical Plants, Domestic Use and High Alloy Steel for Oil Production (Dr. T. Kudo, Head)
- Materials for Atomic Energy Uses (Dr. H. Nagano, Head)
- High Temperature Corrosion (Dr. Fujikawa, Head and Dr. Shida)
- Materials for Oil Country Tubular Goods: Low Alloy Steel (Dr. A. Ikeda, Head)

Group 1. This group is concerned with the development of more corrosion resistant alloys for the chemical process industry and various domestic uses. It also does the alloy development needed for the more demanding oil well conditions, e.g., alloys of the basic composition: Fe-20Cr-25Ni-5Mo and 50Ni-25Cr-18Fe-6Mo-1Ti. Current research focuses on the development of the duplex phase stainless steels for the chemical process industry, of ferritic stainless steels for automotive use such as trim, wipers and wheel centers, and of austenitic and duplex stainless steels for geothermal applications.

Group 2. Current research continues on stress corrosion cracking in alloys used under conditions encountered in both pressurized and boiling water reactors and in liquid sodium-cooled fast breeder reactors.

Group 3. Oxidation processes in gases are studied with a current emphasis on steam oxidation problems, corrosion-erosion by coal ash, and materials development for coal liquefaction.

Group 4. This group seems to be particularly active (in addition to the oil well alloy studies mentioned in Group 1). I was not shown the laboratory for oil well and H_2S studies, an area of strong competition from both domestic and European rival steel companies.

Steels containing a low level of Cu (0.2-0.4 wt.%) and certain other elements are known in the industry to have improved resistance to hydrogen induced cracking. Ikeda and co-workers are studying the conditions, environmental and metallurgical, for which improved resistance is obtained in these alloys to be used as line pipe. They conclude at this time that the Cu addition leads to an improved barrier layer to hydrogen permeation, a hypothesis which has merit at pH $\gtrsim 4$ where a solid reaction product is stable and where a noticeable improvement in resistance to hydrogen induced cracking has been observed in laboratory tests. Cobalt at levels over 1% is also effective for reducing hydrogen absorption even at low pH.

Dr. F. Terasaki, who is in the administration of the Central Research Laboratory maintains an activity in this research problem. He, with Ikeda and others in the laboratory, have published extensively on the subject. A synopsis of their thinking on the matter goes something like the following. From a point of view of the protection of the low alloy steels from hydrogen cracking in wet H_2S environments, it is necessary to keep the concentration of hydrogen dissolved in the steel, C_o, below a threshold value for cracking, C_{th}. Having concluded that $C_o < C_{th}$ is the important design criterion in order to avoid cracking, they have investigated the factors which affect C_o, e.g., types of solution, pH, partial pressures of H_2S and CO_2, and alloying element, and those that affect C_{th}, e.g., segregation, shape control of inclusions and the microstructure. Thus, by use of the $C_o < C_{th}$ criterion for avoiding hydrogen cracking, they believe that in the future alloy selection will be assessed from a knowledge of the partial pressures of H_2S and CO_2 and other environmental factors such as the temperature.

THE INSTITUTE FOR SOLID STATE PHYSICS, UNIVERSITY OF TOKYO

History and Objectives

The Institute for Solid State Physics (ISSP) of the University of Tokyo was established on April 1, 1957, upon the recommendation of the Science Council of Japan and with the concurrence of the Ministry of Education and the Science and Technology Agency. Professor S. Kaya was the first director (1957-59). His successors were Professor T. Muto (1959-65), Professor S. Miyake (1965-68), Professor T. Suzuki (1968-73), Professor J. Yamashita (1973-76), Professor K. Yoshida (1976-81) and Professor S. Nakajima, the present director since April 1981.

The major function of the Institute is to carry on basic research in the solid state sciences and their related fields making use of the most advanced instruments, some of which are only available at ISSP within Japan, and a close collaboration with scientists in other institutions abroad as well as in Japan. Research opportunities are also provided for graduate students, postdoctoral fellows and scientists to do research work in the Institute. In this capacity the author recently spent four months at ISSP as a University Invited Professor interacting with faculty and students in the Surface Science Group.

The initial organization of the Institute for Solid State Physics was such that it would undertake research in every major field of solid state science with the intent to catch up to the international level at that time. Recently, however, considerable effort has been exerted for the development of new techniques designed to make the ISSP a leader in the international science community. These techniques include producing megabar pressure, micro-Kelvin temperature, mega-Gauss magnetic field, subpicosecond laser pulses and clean solid surfaces in extremely high vacuum.

Its own electron storage ring for synchrotron radiation is operated in collaboration

with the Institute for Nuclear Study of the University of Tokyo. Neutron scattering experiments started and currently being conducted in the Japan Atomic Energy Research Institute at Tokai are also now carried out in close collaboration with scientists at Brookhaven and Oak Ridge National Laboratories as part of the Japan-US Cooperation Program.

These new research projects of larger scale, in conjunction with many individual activities of smaller research groups, are expected to advance the frontiers of solid state science in the near future. This is the prospect open to the Institute for Solid State Physics in 1982, the 25th anniversary of its establishment.

Organization

The total number of staff is about 210, including 50 faculty members, 50 research associates, 80 technicians, and 30 secretaries. Besides staff members, about 60 graduate students work in the institute. Since ISSP is an Institute open to any scientist in the country for collaboration, it hosts about 400 visitors each year supported financially by ISSP. The faculty determines the policy for the administration of the Institute taking into account the recommendations of the Advisory Committee. The faculty consists of all professors and associate professors of the Institute. The members of the Advisory committee are elected, mostly from outside and some by the faculty of ISSP. During the fiscal year, April 1981 to March 31, 1982, $10 million were spent for facilities and research, exclusive of personnel expenses which were over $4 million. Almost all of the funds come from the Department of Science and Education.

The organization of the research groups within the Institute is based on the large scale projects and facilities required for doing basic research on matter under extreme conditions, as well as for research on condensed matter and for theoretical studies. Accordingly, there are the following groups conducting research at the ISSP.

. Solid State Physics Under Extreme Conditions

- High Magnetic Field
- Laser Physics
- Ultra-low Temperature
- Surface
- High Pressure
- Synchrotron Orbit Radiation
- Neutron Scattering and Diffraction

. Condensed Matter Physics

- Low Temperature Conduction Electrons
- Electron-Lattice Interaction in Solids
- X-ray Crystallography
- Magnetic Resonance
- Ferroelectrics and Structural Phase Transitions
- Crystal Growth
- Semiconductors
- Crystal Plasticity
- Molecular Structure and Spectroscopy
- NMR in Magnetic Materials

. Solid State Theory

. Laboratories for Joint Use

. Guest Staff Division

. Service Section

In what follows the research activities of the Surface Science Groups of this large and impressive institute are (briefly) presented. The Laser Physics Group was recently described in the *Scientific Bulletin, 7,* (1) 45, (1982).

Surface Science Group

The Surface Science Group consists of three subgroups headed by Associate Professor Y. Murata, T. Sakurai, and a third faculty member to be added soon. This group, being relatively new (Professor Murata, the first professor in the group, joined the Institute in 1976), is particularly well funded with a three year budget from April 1982 to March 1985 of approximately $1.8 million. The main goal of the group is to develop a few of the most advanced and powerful surface research instruments and apply them for the comprehensive investigation of fundamental problems in surface science. Among secondary goals are:

- to coordinate the research interests of both physicists and chemists in the Institute, and

- to establish a center of surface science research in Japan.

Understanding clean surface reconstruction is emphasized, not only for its own sake but also for understanding the basis of chemical reactions taking place on these surfaces. Since the group is new, Professors Murata and Sakurai are busy designing and constructing several instruments, the following of which are currently available or to be completed in the near future.

- Electron spectroscopy for investigating surface electronic structures

  . ultraviolet photoemission spectroscopy
  . synchrotron photoemission spectroscopy
  . ion neutralization spectroscopy (to be constructed)

- Electron spectroscopy for investigating surface vibrational structures

  . time-of-flight low energy electron spectroscopy
  . high-resolution electron-energy-loss spectroscoph (to be added)

- Microscopy for investigating atomic structures

  . UHV scanning transmission electron microscopy (to be constructed)
  . atom probe field ion microscopy

- Diffraction apparatus for surface investigations

  . VTR equipped low energy electron diffraction
  . atomic beam diffraction for well-defined clean surfaces

- Apparatus for investigating chemical reactions

  . molecular beam scattering
  . ion beam scattering using very low energy ions

The staff of Professor Murata's group and its work are as follows:

Y. Murata, Associate Professor
H. Tachihara, Research Associate
H. Daimon, Technical Associate
M. Kubota, Technical Associate

The atomic and electronic structures of the crystalline surfaces of metals, metal oxides and semiconductors are investigated using low energy electron diffraction, electron energy loss spectroscopy and photoelectron spectroscopy with He resonance lines and synchrotron radiation. The electronic structures and ion-molecule reactions during chemisorption are also studied for the purpose of revealing the origin of catalytic activity and selectivity.

Current investigations are on the following subjects:

- structural changes on the MgO(001) cleaved faces,
- phase transition in alkali metal overlayers on semiconductors and metals,
- relationship between catalytic properties and surface properties,
- ion-molecule reaction of very low energy ions with chemisorbed molecules,
- photoemission spectroscopy using synchrotron radiation,
- time-of-flight electron spectroscopy for investigating surface phonons,
- molecular beam scattering for investigating chemical reactions on surfaces,

The staff of Professor Sakurai's group consists of:

T. Sakurai, Associate Professor
A. Sakai, Research Associate
A. Jimbo, Technical Associate

Professor Sakurai's group, just one year old, is currently constructing several instruments in the areas of field ion microscopy (FIM) and ion neutralization spectroscopy-atomic beam diffraction (INS-ABD). In FIM, the construction of a high-performance atom-probe (field ion microscope) has almost been completed and investigations of various problems in materials science will begin soon. The initial studies will include:

- surface segregation in binary allows, such as Ni-Cu and Ni-Cr,
- grain boundary segregation in Ni and Fe-based alloys,
- initial oxidation of nickel.

Apart from those applications of FIM, the new atom probe is capable of detecting and analyzing neutral atoms coming from emitter surfaces. This is one of its unique features and is expected to be useful in studying the basic physical processes of field evaporation and desorption.

The subgroups also include several postdoctoral fellows and a dozen graduate students coming from the Physics and Chemistry Departments of the Faculty of Science as well as from the Applied Physics Department of the Faculty of Engineering at the Main Campus of the University of Tokyo.

There is also a theoretical group collaborating with these experimental groups. it consists of Professor S. Sugano and Associate Professor K. Terakura. Professor Sugano is interested in, (1) geometrical structures of semiconductor surfaces, such as Si(111) and Si(100) and, (2) dynamic processes of particle-surface interactions. Professor Terakura, currently on sabbatical leave at IBM T. Watson Research Laboratory, Yorktown Heights, is active in, (1) the geometrical structures of metals such as W(100) and Mo(100) and, (2) surface phenomena involving defects such as grain boundary segregation and vacancy movements.

In addition, Professsor K. Hirakawa, an expert of neutron diffraction, is also interested in surface phenomena. He has been applying polarized neutron beams to investigate surface magnetism. Furthermore, the Synchrotron Radiation Group (Professor A. Kanzaki, Associate Professors, S. Suga and G. Miyahara), is active not only in maintaining the present facility but also in designing a new storage ring with high beam intensity. The Surface Science Group has their own beam line in the present facility. The new photoemission apparatus has just been connected to the line with a UHV grating monochrometer designed at ISSP and is expected to produce high quality data in a few months.

In summary, the author's impression is that research in the surface science area, though still in its infancy at ISSP, looks particularly strong. Once start up preparations are completed productivity and quality should be very high.

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INTERNATIONAL SYMPOSIUM ON CHEMICAL KINETICS RELATED TO ATMOSPHERIC CHEMISTRY

J. R. McDonald

The International Symposium on Atmospheric Chemistry was held this year on 6-10 June 1982 at the Tsukuba Center for Institutes in Tsukuba, Ibaraki, Japan. The symposium was sponsored and supported by The Japan Society for the Promotion of Science, The Commemorative Association for the Japan World Exposition and the Chemical Society of Japan.

The Tsukuba Science City is perhaps a unique manmade phenomena. The Science City has been planned and built by the government to "enable institutions to undertake research and educational activities in a comprehensive and organized manner." The construction began in 1966 in an area near Mt. Tsukuba approximately 60 km northeast of Tokyo on a site of 28,650 hectares. The city of 130,000 now contains two universities, thirty one government research institutes, seven other government facilities, six government enterprise facilities and seven new private institutes.

The symposium sessions were held at the Tsukuba Center for Institutes which is a facility designed to house international conferences. The main conference hall will seat 200 in a setting very similar to the main meeting room of the United Nations in New York City. In addition, the facility has various seminar rooms, a reference room, dining facilities and a sports complex. The site is also well-suited for visits to various Japanese Government research institutions carrying out studies related to atmospheric processes. Wednesday afternoon, 9 June, was set aside for escorted visits by meeting participants to several laboratories.

One group of visitors toured a portion of the National Laboratory for High Energy Physics. The main installation here is the proton synchrotron which is a 340 m circumference ring designed to accelerate protons to 12 GeV. Also under construction and near completion is the synchrotron radiation research facility which is referred to as the "Photon Factory." This factory consists of a 400 m long 2.5 GeV electron accelerator. The light from the synchrotron facility will be used to conduct experiments in physics, chemistry, biology and medical science. (See Dr. Fisher's article in this issue for a more complete description of this facility).

Another group visited several research laboratories at the National Institute for Environmental Studies. This included a tour of the LIDAR facility located in an observatory dome at the highest point of the location. The large Nd:YAG laser system can be used to continuously three-dimensionally map pollution distributions and atmospheric structures by remote sensing. A tour was also conducted through the phytotron which includes several large artificial light chambers and monochromatic light rooms where environmental factors such as light, temperature, wind velocity and pollution concentrations on plant growth can be studied. Food crop plant strains are being developed which are more tolerant of SO_2 and other atmospheric contaminants.

The main highlight for this tour was the 6 m^3 smog chamber facility at NIES. Studies at this facility were presented at the symposium. The entire chamber can be baked and evacuated to ultra high vacuum. The light sources are 19 1kW high pressure Xe arc lamps filtered to approximate sunlight. The chamber is completely automated and instrumented and includes a several hundred meter path-length FTIR system as well as more conventional sampling and monitoring instrumentation. Data processing and computing facilities are available for modeling studies.

The symposium was attended by approximately one hundred participants from Japan, United States, United Kingdom, Germany, France, Korea, Canada, Australia and New Zealand. Somewhat more than half of the participants were Japanese with a large participation from both universities and government research facilities. The scientific program consisted of forty-two invited (thirty-five minute) and contributed (twenty minute) papers and a poster paper session. Because of the limited size of the meeting it was not necessary to conduct parallel sessions. The twenty-four poster papers were presented during a single informal session Monday evening which lasted several hours both because of keen interest in the scientific material and because of the unlimited refreshments which supported the informal atmosphere.

About half of the papers presented during the meeting directly concerned chemical reactions, kinetics or monitoring of atmospheric species. The remainder of the papers were in related areas which include photochemistry, combustion chemistry, ion interactions, molecular dynamics, spectroscopy, optical diagnostics, molecular beam and laser techniques. These latter areas either impact indirectly upon atmospheric processes or represent the development of techniques or instrumentation relevant to atmospheric species monitoring or the measurement of important chemical interactions.

There occasionally arise issues relating to the atmosphere which are of worldwide importance or have a particular relevance or urgency associated with them. These include issues such as the effect of freons or supersonic transport planes on the ozone cycle, the importance of natural or manmade airborne particulates, the probable effects of long term production of CO_2 from fossil fuel burning, the causes and problems associated with acid rain or the atmospheric effects of deforestation of major land masses to produce paper and wood products. None of these problems are isolated by the borders between countries or by the oceans between continents. For these reasons issues relating to atmospheric chemistry are particularly relevant subject matter for international symposia.

An understanding of phenomena such as those alluded to above is never the result of an easy experiment or series of experiments. Often just the definition of the existence or scope of an atmospheric problem takes years of study. The process of definition invariably requires the discovery of new chemical species or techniques to measure elusive species, the measurement of the reaction kinetics of numerous compounds and radicals, the simulation of atmospheric conditions in large chambers and the extensive modeling of complex reactive systems followed by the testing of the models on the atmosphere. The scientific issues are often further complicated by political or national interests, by the need for food production or transportation or by commercial or industrial interests. Symposia such as this have as an objective the impartial scientific discussion and exchange of information which can lead to an understanding of atmospheric chemistry and a definition of the likely impact of natural or manmade phenomena on the atmosphere.

Rather than discuss individual presentations or the results of particular investigations I will briefly summarize the particular topics, phenomena, or techniques which were the major subject of this symposium. For further details, the reader is referred to the meeting abstracts. Inquiries can be made to:

Dr. H. Akimoto
Symposium Secretariat
Division of the Atmospheric Environment
National Institute for Environmental Studies
P.O. Tsukuba-gakuen, Ibaraki 305 Japan

In essentially all cases the material covered in an abstract is the subject of publications in the scientific literature.

There were eighteen papers presented which directly reported upon measurement of species in the atmosphere, the measurement of atmospheric chemical reactions or on atmospheric modeling. Of particular relevance to the subject of the symposium and to historical development of the field were papers by Calvert (NCAR) and Heicklen (Pennsylvania State University) on production and evolution of aldehydes in the atmosphere and a presentation by Herron (National Bureau of Standards) on tropospheric ozone reactions. The results of experimental and modeling studies in large instrumented smog chambers were presented by Akimoto (NIES) and Becker (Wuppertal University). Mulcahy (Commonwealth Scientific and Industrial Research Organization) presented studies of OH reactions with hydrocarbons from their 20 m^3 outdoor smog chamber. Tsuruta (Yokohama Research Institute) presented modeling studies for minor constituents in the troposphere.

There were several papers dealing directly with halogen species in the atmosphere. A review of the freon measurements in the atmosphere as well as a discussion of its fate and major reaction chemistry was presented in an excellent paper by Rowland (University of California, Irvine). Several other papers relevant to the freon problem dealt with the reaction chemistry of chlorine containing species. Included are papers by Zellner (Gottingen University) on ClO, studies on Cl and ClO by Howard (National Oceanic and Atmospheric Administration) and a study of a range of oxyhalogens by Molina (University of California, Irvine).

The study of odd oxygen chemistry is also relevant to the freon removal via the OH radical. In addition these studies also impact on the ozone cycle, and, NO_x and hydrocarbon oxidation processes in the atmosphere. A partial list of these reaction studies include O atom chemistry by Ogryzlo (University of British Columbia) and Sato (Tokyo Institute of Technology), OH and HO_2 by Howard (National Oceanic and Atmospheric Administration), LeBras (CRNR-CRCCHT) Ohata (*Tokyo Metropolitan* Research Laboratory), Becker (Wuppertal University) and Heicklen (Pennsylvania State University), O_3 by Herron (National Bureau of Standards) and HO_x by Cox (UKAEA). Studies of alkoxy species were presented by Ebata (Tohoku University) and Batt (University of Aberdeen).

Eight papers were concerned with chemistry or species which are involved in combustion or have their origin in combustion devices. Hatakeyama (NIES) presented a paper dealing with oxidation of organo-sulfur species. Using long path-length FTIR Niki (Ford) carried out similar studies. Ogawa (Kyushu University) used electron bombardment to generate and study the C_2 species. Primary reaction Chemistry of C_3 with flame gases was reported by McDonald (Naval Research Laboratory). Extensive CH reaction studies were reported by Lin (Naval Research Laboratory). Chemical reactions of NH were studied by Kondo (Osaka University) and laser techniques to produce NH were reported by Stuhl (Ruhr University) The chemical reaction rates for H, N, and O atoms with olefins were discussed by Sato (Tokyo Institute of Technology).

Several papers were either devoted to or heavily involved discussion of the development and application of modern diagnostic techniques for chemical and species characterization. Some examples are given below. FTIR long path-length spectroscopy was an important diagnostic tool used in the studies of Niki (Ford) and Molina (Univeristy of California, Irvine). Microwave spectroscopy was used in the studies of Endo (Institute for Molecular Science) and Uehara (Sagami Research Center). Several laser based techniques were used for specific applications. UV-visible laser techniques have been used

to produce and characterize many species. Donovan (Edinburgh University), in an invited paper, discussed the excimer laser multiphoton dissociation of several species. Similar techniques were used for the generation of several radicals such as C_3 and CH by McDonald (Naval Research Laboratory) and Lin (Naval Research Laboratory). In other cases laser spectroscopy has been used to characterize particular species, i.e., HSO by Kawazaki (Mie University), HNO by Obi (Tokyo Institute of Technology), and Cl_2 by Ishiwata (Tokyo Institute of Technology). Scanning diode laser spectroscopy is becoming a very powerful technique for detecting and characterizing species. An excellent example is the work reported on the CH_3 radical by Yamada (Institute for Molecular Science). Laser magnetic resonance studies were reported in an invited paper by Howard (National Oceanic and Atmospheric Administration). Multiphoton ionization techniques were reported in papers by Achiba (Institute for Molecular Science), Hudgens (Naval Research Laboratory) and Shinohara (Institute for Molecular Science).

Another technique which has had almost as profound an effect on gas phase studies as the laser in what is becoming the very wide spread use of beams for the study of photodissociation, spectroscopy, ionization, and molecular interactions. Nine papers in this Symposium employed molecular beam techniques for various types of studies. Perhaps the most elegant of these are the TESICO experiments such as reported by Achiba (Institute for Molecular Science) and Kato (Institute for Molecular Science). Lee (University of California, Berkeley) uses classical crossed beam techniques to study O atom collisions with olefins. Ogawa (Kyushu University) has crossed molecular beams with electron beams. Several others have carried out spectroscopic studies by crossing optical and molecular beams, i.e., Obi (Tokyo Institute of Technology), Koda (Tokyo University) or photodissociation studies in a molecular beam, Kawasaki (Mie University) and Nishiyama (Institute for Molecular Science). Molecular cooling in supersonic beams has been used to form NH_3 clusters for MPI studies, Shinohara (Institute for Molecular Science).

Following the meeting at Tsukuba two satellite meetings were arranged. Each of these were attended by a subset of the participants at the Tsukuba Symposium. The first of these was the Informal Symposium on Reaction Dynamics which was held at the Institute for Molecular Science in Okazaki on 12 and 13 June. There were ten invited speakers at this meeting which was attended by 65 participants.

On June 14, a second satellite meeting was held on the island of Kyushu in Fukuoka at the University of Kyushu. This was the International Symposium on Photochemistry and Chemical Reactions. The meeting was hosted by Professor Ogawa of the Department of Molecular Science and Technology at Kyushu University. Seven invited papers were presented.

JAPAN'S FIFTH GENERATION COMPUTER PROJECT

Richard Dolen

INTRODUCTION

A new research project in information processing sponsored by the Japanese government has recently been officially announced at an international conference held in Tokyo. This ambitious project will fund research and development on computer systems appropriate for the society and technology of the 1990s. The undertaking of this effort signals Japan's intention to become the world leader in a field which is becoming increasingly important in its technological and economic consequences. The demonstrated effectiveness of Japanese research and development in other fields such as steel and consumer electronics should be lesson enough to those who would ignore the potential impact of this new effort on our lives.

Computer scientists in Japan have designed a ten year research plan aimed at developing prototypes of new computer systems which would be appropriate for the society of the 1990s. Called Fifth Generation Computer Systems, they would be characterized by extreme ease of use, flexibility of application, and speed. Computers will have so permeated society by the next ten years that there will be a great demand for almost universal computer access to assist in a great range of tasks. In addition to the current media of cards, keyboard, and tape, the systems would accept pictures, graphs, and natural language input either by voice or handwriting. Application programs using sophisticated techniques of artificial intelligence would enable the machine to comprehend the natural language input sufficiently well to produce automatic translations from one language to another. In operation these programs would refer to knowledge bases containing information about languages and their rules, as well as knowledge bases containing ordinary common sense information about the world so that the machines could carry on question and answer conversations with the users. Other knowledge bases would contain information about the machine resources and techniques of programming so that the machine itself could compose reasonable programs to respond to requests which had been clarified by interaction with the user. The computer architecture to be used in the new systems may be characterized as a combination of communicating machines, each adapted to a particular processing function such as relational data base handlers, logical inference machines, or functional machines. Each such type of machine may be in effect a collection of multiprocessors working together with a high degree of parallelism to perform its job very efficiently, so that combined with advanced chip technology, factors of 10,000 in performance over current machines may be achieved.

To formulate and reach these goals, the project organizers have worked for two years tracing the latest developments in computer science and laying out a coordinated plan of research and development. The task will be divided among 26 groups, made of researchers drawn from universities, government laboratories, and industry, communicating their results to each other in prescribed ways over a computer network. The organizers have identified a number of fundamental problems, both theoretical and practical, for which creative solutions must be found, and suggested promising directions of research. But it is impossible to say with certainty whether acceptable solutions can be found in ten years. This element of risk, plus the length of time before results appear make this project too difficult for private funding. However, because of the great benefit to Japan of even a partially successful outcome and the importance of starting as soon as possible, it has been adopted by the government as a national project.

Another of the announced goals of the project is to make Japan the perceived world leader in information processing. If this were to happen, Japan would lay claim to a large share of the world computer market and make a severe dent in the United States' computer industry. The U.S. computer industry seems largely unaware of these developments or their significance. Steps should be taken to keep abreast of the progress in Japan, and to promote similar basic research in information processing here in the United States. The possibility of U.S.-Japan collaboration in certain research areas should be seriously explored.

The report was prepared in the United States based on experiences and materials gathered in Japan in a one month period in October-November of 1981. The principal experiences were attendence at the International Conference on Fifth Generation Computer Systems, tours of several industrial research centers, visits to computer research centers at the Universities of Tokyo, Kyoto, and Osaka, and interviews with officials of a few Japanese government agencies concerned with information processing -- JIPDEC (Japan Information Processing Development Center), JIPDA (Japan Information Processing Development Association), and JICST (Japan information Center of Science and Technology). These sources were very generous in making available many documents in English and Japanese, and they were supplemented by other books and periodicals in the open literature. At the end of the Japan visit one was left with the impression of having seen only a surface glimpse of a very large enterprise. But the range of technologies and subjects was even then so broad that it would have required a well-developed expertise in all of them to absorb and digest all the material encountered.

MOTIVATION FOR PROJECT

There are very few projects undertaken which have at their outset as many good reasons to begin them as does this one. The working group found excellent reasons why this project is good for mankind, good for Japan, good for information processing. These reasons will be discussed first, and then some additional ones, perhaps not less important to the funders of the project.

Information processing is in some ways an ideal industry for Japan. It requires no material natural resources, is not energy intensive, and would be at home in a country which has one of the most highly trained labor forces in the world. These very general considerations would apply equally well to any information processing project. The goals of the Fifth Generation Project arose from considering more specifically the probable requirements of the decade of the 1990s, by which time the ordinary development of information processing technology would be quite advanced, and its applications deeply rooted in many phases of society.

A principal requirement of information processing in the 1990s is to increase productivity in all sectors of Japanese life. Current computer systems have been successful in increasing productivity in manufacturing and administrative data processing, but more and more of the labor force is shifting to low productivity areas such as white collar work, service industries, and product distribution. For Japan to continue its current growth rate, these areas, as well as agriculture and fisheries, must show substantial increases in efficiency. For this to happen, information processing must address the needs of ordinary workers and be accessible to them (not just programmers) in their normal workplaces (not just large office buildings with computers). It must handle documents, pictures, and voice data in large quantities and be able to retrieve them in meaningful ways by simple requests in Japanese. It must aid in decision making by being able to process the content of the material stored rather than merely, say, its document number or other

feature known at input time to be a subject of future inquiry. It must respond to somewhat vague queries in a few specialized fields, much as a human expert might do. The process by which information banks are constructed for such specialized fields must be made simple. To aid in international exchange, translation of written materials between Japanese and English must be accomplished with little human intervention. Typical problems in economics, weather forecasting, and energy conservation involve running a series of computer "experiments" on models and simulators. Computers must be big enough and fast enough so that these multiple runs may be accomplished in reasonable periods of time. By the 1990s, a significant fraction of the population of Japan will be older than 60. It would be important if computers could enable such persons to continue to lead meaningful lives by increasing possibilities of working at home, receiving instructional assistance, or at the very least, having their welfare and medical benefits efficiently administered. Computer systems must be perfected which are secure against unauthorized access to confidential information or destruction of critically needed information. These systems must be available in a wide variety of sizes, from personal computers to giant research centers, and their functions must be modularized to allow for specialization and efficiency. This demands proper standardization of internal machine languages and logical interfaces between the modules as well as a communication technology supporting the formation of large networks of machines.

This rather extensive, and even somewhat, fantastic "wish list" arrived at by the working group studying the requirements of the 1990s does not represent a collection of independent problems each requiring a fundamental breakthrough. As will be explained later, almost all the items on it have one or two theoretical features in common, so that if a substantial breakthrough should be made in any one of them, progress in all the others would, in principle, have been immediately accomplished. The other side of the coin is, of course, that should these common features prove intractable, no meaningful progress could be expected in any of the items.

The rewards to Japan for successful accomplishment of a good portion of these tasks would be considerable, and these rewards have also been spelled out by the planners. It would give Japan the position of world leadership in information processing. This would be not only a boost to the self-esteem of the country, but would be accompanied by the many marketing advantages which accrue to Number One. Though not spelled out in the Conference Proceedings, the markets of China and many third world countries would more readily look toward Japan rather than the United States or Europe. Of course, any progress made in the processing of Japanese language characters would be relevent to the corresponding problems in Chinese. While the Proceedings skim rather lightly over any mention of capturing any other country's current share of world trade it would be naive to assume that this idea is not a motivating factor. In particular, many researchers seem to take it as a personal insult that IBM's share of the world computer industry is so large compared to that of Japan. These sentiments were heard so often, and everywhere in the same words, that they may well have been diffused from a common source. Researchers from IBM Japan were not among the researchers from Japanese industries who participated in the working groups preparing the research plan of the Fifth Generation Computer System. Needless to say, these sentiments do not appear in the Proceedings.

Even if the project should fall considerably short of its goals, there are many advantages in pursuing it. This would mean that the problems attempted are very difficult, and any other research groups are going to find progress equally slow. Japan will have gained many advantages for the information processing industry by ten years of coordinated research linking universities to each other and to industry. The discoveries made along the way will provide the industries with new products and incentives, much as

did the U.S. moon project with its numerous spinoffs. Of course, it will equip many university research laboratories with substantial material facilities which will remain useful beyond the project lifetime. The project itself will give the Japanese valuable experience in this method of attacking national goals by means of long-term integrated research and development. Most previous projects have had lifetimes of three to five years, and have been confined to development and improvement in Japan of techniques which existed in some workable form elsewhere. This project introduces the large risk factors associated with basic research in an area where no one can be sure that the goals are accomplishable. Of course, the time alloted to such a project must be longer and the structure must be such as to encourage the taking of risks by the researchers without fear of punishment for failure.

Since the project is intended as a supplement to the normal stream of current development efforts, its aims begin at the level where current developments are expected to have arrived by that time. If the methods and techniques to be used at that future time were to be the same as those used now, it would be unreasonable to assume that a group of researchers could suddenly start work at a level ten years more advanced than the rest of the industry. This would be a kind of presumptuous attempt at "leap-frogging," to use a phrase appearing in the Western press *(Business Week)*. As will be explained later, the feeling from many different working groups of the project is that the current technology has inherent limitations which will be a severe handicap in advancing beyond a certain level of power and efficiency for important tasks of the 1990s. It is felt that other technologies, both of software and hardware, will be required for those tasks. The effective lag time between the inception of research in these new techniques and their development into practical tools is expected to be long, in the range of ten years or more, and hence not likely to be undertaken by industry in the natural course of economic life. If this is true then now is indeed the correct time to start the planning and research effort. As will be demonstrated later, the seeds for the new technologies are, and have been, the topics of research in universities and even industrial research laboratories throughout the world; the Japanese effort seeks to select, organize, and promote work on them and focus this work on specific practical goals. Thus, although the goals themselves exhibit a great gap compared with those of current manufacturers, the research effort leading to them forms a historical continuum with the world community.

CHRONOLOGICAL DEVELOPMENT OF THE PROJECT

- Origin of Project

This section briefly traces the work done on the project up to the present and describes the stages of future development. The Japanese government has a large number of agencies concerned with information processing, and has both in the past and present sponsored a large number of projects in this field. One of these projects was the Pattern Information Processing System which received 22.0 billion yen (about $100.0 million) between 1971 and 1980. The monies were divided about 35%-65% between the government's Electrotechnical Laboratory and industry, and included research on devices and materials, information processing systems, pattern recognition systems, and an integrated system prototype. The pattern recognition systems were concerned, in particular, with recognition of Japanese written characters, pictures, objects, and speech. This project made progress, but left much to be done in these areas. In many ways, the flavor of this earlier project is the same as that of the Fifth Generation Computer System. The planning stage of the new system began some two years ago, just when the earlier project was coming to a close. Also, since many of the persons active on the earlier project are active in the new one, it is difficult to avoid the conjecture that the new

8roject is in some sense an outgrowth of the earlier one with enlarged scope and updated goals. Whatever the details of the project genesis, the planning study of the new computer system ended up in a proposal for the Fifth Generation Computer Systems project.

- Name of Project

The project takes its name from a way of dividing the history of the development of computer technology into periods, or generations, each characterized by a particular technical feature. Thus, the first generation was characterized by the use of vacuum tubes, the second by transistors, the third by integrated circuits, the fourth by very large scale integrated circuits (VLSI). We are currently in the end of the third generation. The later '80s will be the fourth generation, and the fifth will presumably be in the '90s. At first sight, the name thus suggests that the project includes work on similar new technologies such as Josephson junctions or gallium arsenide semiconductors, and this might have been in the original conception. The project as it emerged from the study phase had consciously decided that research on this aspect of new technology would be more properly placed in a separate project called the Super Computer Project, and the Fifth Generation project, despite its name, would advance at its own pace without waiting for progress in that other aspect of computer hardware. There are enough other technological innovations in the new project to amply justify the christening of a new generation.

- Working Groups

The first step in the planning phase of the project was to divide the problems up into a number of topics and assign each to a working group. These groups worked dilligently, held periodic meetings, wrote reports and contributed their results to a planning group which reached a consensus on the project plan.

The reports of the working groups and the final summary report, all in Japanese, constitute an impressive bulk of material some 1800 pages long. They were available in a handsomely boxed edition purchasable at the International Conference.

One is impressed in looking at these reports by the thoroughness of the consideration paid to the work done in the United States and Europe. The references in each field scan a substantial time period and end with current work. In the fields with which I am familiar, the coverage seems comprehensive. It is difficult to assess the degree of mastery of the material covered or the current fluency of the Japanese researchers in applying the techniques described in these references to their own work. It cannot be said, as a reaction to the boldness of some of the project research objectives, that they are merely the free imaginings of novices; the planners have done their homework. Visible also in these reports is the effort at selecting the most promising avenues of research for the attainment of each goal.

By the time the reports were written and assembled in a coherent strategy for the Fifth Generation project, a number of common themes had emerged. Without the time for a detailed reading of the entire reports, it is difficult to say how much of the conclusions embodied in these common themes was derived entirely by the working groups, or on how much was already present in earlier research papers consulted. Doubtless, the themes emerged to the central level with a greater sureness and clarity because of the communication among diverse groups which were focusing their separate areas of expertise on the solution of a common problem:

- The theme that the current (and fourth generation) computer languages and architecture would be inadequate to perform the functions needed by the 1990s is common to all the working groups.

- The theme that certain types of new computer language offered a possible solution came from the groups working on applications such as machine translation, the groups working on automatic software development, and the groups working on knowledge based systems.

- The theme that certain computer architecture employing a high degree of parallel processing would be the most promising realization of the computer languages described in item two above came from all the working groups on computer architecture.

That the same key ideas emerged from separate groups must have given the planners a strong sense that they were on the right track. With these ideas as a core, the image of the new systems began to emerge. As long as there was a unified structure to the project it became possible to add on more peripheral topics so that many major research groups active at that time could be brought into the project. By June 1981, the investigations and proposals of all the working groups had been assembled into a comprehensive plan of research.

- International Conference

The Fifth Generation Computer System was announced at an international conference held in Tokyo the week of October 19-22, 1981. It was heralded by major newspaper coverage and some care was taken in preparing the invitations. The list of 324 participants shows 242 Japanese, 38 Americans, and 44 Europeans; the list of 18 speakers and panelists shows 12 Japanese, 4 Americans, and 2 Europeans. The Japanese spoke in Japanese, while the Americans and Europeans spoke in English. The proceedings were available in both languages by simultaneous translations accessible through earphones distributed to the participants and the press. Portions of the conference appeared in TV news broadcasts. The entire conference was well-organized, held in excellent facilities, and smoothly run. The Proceedings, in English, were distributed to everyone and corresponded to the subjects of the talks. The handsomely boxed set of working group reports, in Japanese, were available for purchase. The talks by the Japanese were very general in nature, and much less detailed than the corresponding material in the proceedings. The material in the proceedings were, in turn, very general by comparison with the materials in the working group reports and summary. Without a knowledge of Japanese therefore, most of the foreign participants had no access to the specific details of the project plans. They were thus deprived of much of the reasoning the project leaders used to decide among several key research options, and many finished the conference without any appreciation of the quantity and quality of the work which had preceded development of the research plan. For each listener, the feeling of vagueness was strongest in those areas different from his area of expertise; there were almost no pedagogical talks giving simple definitions of some commonly occurring concepts and phrases.

The nominal purpose of the Conference was to present the results of the study groups to the world information processing community, and to solicit its cooperation and criticism. In the pursuit of this purpose, the project targets were each justified in terms of the societal needs of the 1990s and later explained on a more technical level. Another, less obvious, purpose was sensed by a number of the participants: to confirm by means of an international exposition the importance of the project to the Japanese themselves, and in

particular to those segments of the audience who would in the near future make the decisions on the level of project funding.

- Phases of Research

The ten year research period is divided into three phases: a preliminary phase of three years, an intermediate phase of four years, and a final phase of three years. A complicated plan presented in the proceedings describes the information flow from each phase of each research topic to the next, but it is unnecessary to describe more than a few of the basic principles here.

The priorities in the first phase include providing each researcher with the basic tools to carry out his research function. In some cases, where the tools that one group wants is the kind of computer that another group expects to produce at the end of the project, the idea is to get by for awhile with less efficient computers which simulate the the functions if not the speed of the future ones. So each group has intermediate target goals for the earlier phases which are considerably less than the ultimate target goals. Several iterations are then planned so that the results of the research performed with the aid of weaker systems are used to develop stronger ones.

A second priority item in the first phase is to attack those basic problems of software theory which are fundamental to all the advanced applications and human interfaces. The kind of progress made here is the crux of the entire project; though much effort will be placed here, it cannot be known in advance whether breakthroughs in these difficult problems will be made or not. Key areas are those in knowledge representation, logical inference, and others related to the concept of machine understanding. Though progress will be monitored regularly on all the research areas, at the end of the third year the entire project, goals, and schedules will be reexamined based on what has been accomplished in these key areas. Because of the necessity of building on what one already has, (or at the least, on what is almost surely in one's grasp) the effective plan time for the hardest problems is effectively only three years rather than ten. If the basic research themes exhibit progress only after the seventh year, then it will be too late to get those ideas into practical hardware for the fifth generation project. Of course any solutions, whenever they come, will be none the less invaluable for future information processing.

The intermediate phase will have many tasks in it concerned with implementing the discoveries or specifications of the first phase. For those topics which were understood well enough to be implemented on firmware for the preliminary phase, the intermediate phase will attempt to implement them on VLSI chips.

The final stage will be aimed at generating prototype Fifth Generation Computer Systems, fully implemented on machines exhibiting a high degree of parallel processing. By this time, the designers will be aided by a whole series of improved systematization tools developed during the intermediate phase, including computer aided design (CAD) systems and VLSI systems.

- Funding and Administration

All of the hopes of the project depend on securing substantial funding for it. Although it has been announced as a "National Project" there are many other worthwhile projects to be funded by the government, and the level of funding even for the first year will not be known until the first or second quarter of 1982. There is also the uncertainty in the continuity of the funding in successive years, as well as the degree of active support by

other means available to the government and traditionally used in national projects: the inducement of cooperation from other segments of society, loans, tax exemptions, other friendly leglislation, tariff or information protection, access to facilities, etc. At the International Conference, in response to a question, the size of the project was announced to be about 200 to 300 persons. The sum of the estimates for each research area of the project given in the working papers is a billion yen (a million dollars) over the 20 year course of the project. It is not clear whether this figure includes inflation over the course of the research period. There is yet no established structure for the administration of the project. Presumably, one will be set up when the funding is settled. The fiscal administration of a project this size is quite routine in Japan, but the scientific administration will present some new challenges. Project monitoring must comprehend a wide range of insitutions including university professors, government researchers, and industrial laboratories each adhering to a differing set of traditional control mechanisms. At times an area of research may have to be emphasized or discouraged depending on its progress, or that of their research area. Certain scientific conventions must be agreed upon and maintained in each group: programming languages, interface protocols, national standards, etc. This is more difficult in a project such as this one where many persons will continue their current research in their current facilities under a new umbrella. As the project advances, scientific communication will be an increasing portion of the effort. Will it be done by using the type of office automation which the project is pursuing? There are even some problems associated with the desires of some groups in the later stages of research to keep their progress from the others in order to exploit it in the service of a commercial product for their company. The organizers of the project have asked for cooperation from countries abroad. How will this be managed in the face of the problems of either obtaining or withholding too much information? The solutions to these kinds of problems will be instructive both in and outside of Japan. Further discussion of this kind will be found in the section on Problems of Cooperation and Competition.

(Editor's Note added in Proof: Japan has made an auspicious start on the Fifth Generation Computer System project by forming the "*Institute for New Generation* Computer Technology." The ICOT, the Japanese acronym of this new institute, will begin functioning in June 1982 under the directorship of Dr. K. Fuchi. Dr. Fuchi is taking a three year leave of absence from Electrotechnical Laboratory (MITI), where he has been leading a team of able computer scientists to develop various MITI-sponsored computer projects, and expects to have about ten ETL scientists assigned to ICOT. About the same number of computer scientists and engineers are expected to take leaves from NTT laboratories to join the ICOT research staff. Eight Japanese corporations (Fujitsu, Hitachi, Mitsubishi, NEC, Oki Electric, Toshiba, Matsushita, and Sharp) are participating in this project and each company is asked to assign about five research personnel to ICOT. Thus, ICOT will begin its ambitious R&D program in new generation computers with 50 to 60 able, young (it is hoped under 35 years old) researchers. So far, three U.S. subsidiary companies in Japan (IBM, NCR, and Univac) are expected to join the ICOT, but the terms for foreign participation have not yet been fully worked out. The funding for the first three years has been assured, at about Y11 billion, or $50 million at $1=Y220 exchange rate. Allocation for the remainder of FY 82 is approximately Y900 million consisting of Y460 million from MITI, Y200 million from KEIRIN (MITI-sponsored bycicle racing association), and Y200 million from the participating industries. For FY 83 and 84 the allocation is Y5 billion each year.)

RESEARCH THEMES

The research plan is divided into twenty six research themes grouped into seven broad categories.

Basic Application Systems
Basic Software Systems
New Advanced Architecture
Distributed Function Architecture
VLSI Technology
Systematization Technology
Development Supporting Technology

In the summary report of the working groups, the discussion of each of these themes includes a motivation for inclusion as a topic, study of the current status of its development, a proposed path of research, and a set of goals for each phase of the research. This material is important and instructive as an introduction to the themes themselves, and as an exposition of their relation to the project as a whole. The material should be translated and made available, but a full presentation here would be beyond the scope of this report. Here there is space and time to touch briefly on the themes, with emphasis on the motivation and goals of each. If there is sufficient interest in the detail, a translation of the summary report may be produced at some future time.

- Basic Application Systems

This category includes five research themes:

- Machine translation system
- Question answering system
- Applied speech and understanding system
- Applied picture and image understanding system
- Applied problem solving system

These themes are the ones which most capture the imagination of the layman, and most arouse the skepicism of the professional. On the one hand, they are the easiest to understand from the user side and on the other, they are the most difficult to bring to fulfillment. They have been the subject of much research over the years, particularly by persons in the field of artificial intelligence, but although some encouraging progress has been made, fundamental problems remain unsolved. One might say that it is in the service of being able to accomplish the goals of these research themes that all the other themes are being pursued. It is a credit to the seriousness of purpose of the organizers of the project that the other themes are present. Otherwise, the project would be seen as merely another attempt at solving a portion of a great problem "in principle" without the intention of pursuing the solution to the level of a practical device.

It is the accomplishment of the goals of this group which will make the Fifth Generation Computer System approachable by ordinary persons communicating much as they would to another person, rather than only by highly trained persons willing to spend long hours communicating by means of a limited and rigorous protocol to a fault-intolerant device.

. Machine translation system

The goal of the machine translation task is to be able to translate automatically from Japanese to English (later to other languages) and vice versa, a wide range of written materials encompassing a vocabulary of 100,000 words. The translation must be 90% error free, the remaining 10% to be completed, where necessary, by a trained human translator, with the requirement that the entire translation process must cost less than 30% of the

cost of a purely manual translation. This is felt to be a task of quite high importance for the country. For purpose of trade, information exchange or foreign diplomacy, Japan can not run her country in English, nor expect more than the most minute percent of the rest of the world to learn Japanese.

Yet the problems of machine translation even between neighboring languages are well-known and have generated a wide research literature. The crux of the matter is that the context of the material must be understood before it can be translated, and this understanding can not be at the level of grammar and syntax alone. Whether a certain Japanese word is translated as heat, fever, or passion depends on whether the subject is thermodynamics, medicine, or love; or perhaps whether the scene is lit by the furnace, the surgical lamp, or moonlight. The imaginative reader realizes further that none of these circumstances is necessary or sufficient by itself, or even in combination with the others, to make the correct choice in all cases. If the machine is to make these choices it must pick up its clues from the meaning of the text, as humans might. It must have at its disposal many common sense facts about the world, and be able to make simple logical inferences and pertinent associations among them. Thus, this task requires the machine to have a knowledge base and an internal language capable of handling logic. Practicable ways to store knowledge (as opposed to data) in the machine and to access it logically are two of the most fundamental unsolved problems in the project. Almost all the tasks will require their solution.

Machine translation is particularly difficult because even after the theoretical problems are resolved, knowledge bases must be built containing information about the words of each language, the grammar of each language, and the general purpose knowledge base. Japanese is a particularly difficult language to translate from because of many linquistic habits associated with it; for example, the preference for omitting the subject of sentences. Translating into Japanese includes the extra difficulty of coupling to output devices which handle the full range of Japanese characters.

. Question answering system

The question answering system will be a facility which in various specialized fields will be able to respond to queries as would an expert in the field. Each field will have its own knowledge base. The target system must be large enough to accommodate some 5000 words and some 10,000 rules of inference. The system will understand rudimentary principles of conversation so that it can ask the user to specify further information as necessary. It will function in such specialized fields as computer aided design, and decision support systems. Later, it will be used as an advanced form of the "expert systems" available now to answer questions in medicine, chemistry, and other technical fields. Again, the basic problem is formulating the structure a knowledge base and designing an access method which will retrieve logical consequences of the knowledge in it. There are also the specific problems of extracting the knowledge from human experts in a form useful to build the machine knowledge base.

. Applied speech and understanding system

The applied speech and understanding system has three goals:

- the development of a phonetic typewriter which can handle 10,000 words, and analyze their meaning sufficiently well to make simple corrections and generate comprehensible sentences,

- a speech responding system with the same word capacity, but aimed at natural conversation,

- a speaker identification system capable of identifying several hundred different speakers from short samples of their voices.

The phonetic typewriter is quite important for Japan's efforts at office automation. The difficulties of processing Japanese text would be hard enough without the problem posed by the enormous labor currently required to input text to a machine. In Western countries, a relatively short period of physical training developes a typist who can produce words 50 per minute. At an average of five letters and one space per word, this is a rate of 18,000 strokes per hour. The cumbersome Japanese typewriters which handle characters directly require a fairly long training period to reach 1,500 strokes per hour, and the same rates hold for those computer input devices utilizing similar techniques. With the mixture of characters, and phonetic symbols with which Japanese is written, there is an average of some three strokes of Japanese writing per translated English word. Thus, the input rate is some eight words per minute, or one-sixth of the rate for Western countries. When this is compounded with the additional Japanese circumstances that the number of typewriters and trained typists is very small, and that the wage of a typist is a much larger fraction of the wage of the person producing the original draft than in the West, we see the enormity of the problem facing Japan. In the typical business office, most documents now are simply handwritten, and reproduced by carbon paper or photocopier. A phonetic typewriter would enable anyone to generate documents and machine input. A related task placed in a different category is the input of documents by machine recognition of handwritten characters. The phonetic typewriter task is difficult because it must combine the problems of machine understanding of language with the phonetic analysis necessary to distinguish words in connected speech. Current research indicates that the difficulty of identifying words in connected speech is almost as great in Japanese as in English, despite the commonly held belief that because of the smaller number of phonemes in individual Japanese words, it should be much easier.

. Applied picture and image understanding system

The goal of the picture and image understanding system is to design a data base capable of storing 100,000 pictures or images; the time to store both a picture and its abstract description must be only a few seconds; the retrieval time should be on the order of 0.1 seconds. Appropriate theory concerning an internal language for an abstract description of a picture must be developed so that pictures may be indexed and retrieved with the same kind of descriptions that humans use when they talk or write about pictures. The pictures discussed here may be such things as charts, engineering drawings, architectural views, medical x-rays, or satellite weather pictures, and the aim is not only to store them, but to be able eventually to process the information contained in them.

. Applied problem solving system

The applied problem solving system has two goals:

- to produce a system capable of solving mathematical problems by combining a knowledge representation system containing sophisticated mathematical algorithms for processing formulas with a problem solving system,

- to produce a system capable of playing the oriental game of go at a level equivalent to a human player rated as amateur first-degree (shodan).

The mathematical problem solver would continue and extend the functioning of systems such as MIT's MACSYMA with an important difference which characterizes most of the tasks of a Fifth Generation Computer System. It would function by converting the current kind of processing into the form of a "knowledge base" containing rules of mathematical manipulation and inference. A problem solving system would then refer to the stored knowledge, and make logical inferences and pertinent associations in its progress toward a solution. The system would handle not only mathematical expressions and equations, but also inequalities which are not handled satisfactorily by MACSYMA. Another characteristic of this task which makes it especially congenial to the philosophy of the Fifth Generation System is that the knowledge base in this case has a very small number of "facts" compared to the number of "rules" for manipulating facts. This characteristic is an important component of the difference between data and knowledge.

Undoubtedly, the system would use a language appropriate to logical inference (as MACSYMA does) for its internal language rather than a conventional processing language. A likely candidate for the internal languages of most of the tasks in this category is an extension of the language PROLOG which has been used with some success in Europe. The most popular language for artificial intelligence work in the United States is LISP (or its relatives INTERLISP, MACLISP). During the International Conference, the only subject on which there was anything approaching a controversy was the Japanese choice of PROLOG as a provisional internal language for the project. A number of participants in the conference took the position that not only was this the wrong choice, but that the Japanese were not yet experienced enough in artificial intelligence work to make the correct choice. However, the wry comments in the reports of the working groups show that the Japanese were experienced enough to anticipate this reaction (at least from the Americans).

The association of a gameplaying task with a national project to assume world leadership in economic areas may seem inappropriate, is and perhaps just the result of some compromise with an important sector of research interest. There is ample justification for the presence of a go playing task in the project, and there does not seem to be any large working group in this field which would have the necessary clout. In fact, there has been more research effort and more success in go playing programs in this country than in Japan.

Chess playing programs may be more familiar to the reader so that they may be used as an explanation of why a go playing program represents a challenge of a different kind. The utility of chess playing programs is that they represent an exercise in techniques of artificial intelligence, and they represent the attainment of a level of skill which can be measured on the same scale as is used for humans. The chief techniques used by the current strongest chess program (Chess 4.7) are search techniques, and a final evaluation algorithm which incorporates some of the human experimental knowledge which can be easily quantifiable. Basically, the program works by searching all possible moves to a fixed depth (say seven moves), using the algorithm to find the highest point value for each resulting situation, then recalling the route which led to the best score in the face of the opponent's best moves. In chess, the average number of possible moves from a given position is about 30, so in a totally blind search to a depth of seven moves one would have to evaluate some 30^7 or $2\ 10^{10}$ positions. There are important improvements in the bare scheme above which eliminate some branches of the search cutting down the number to about $5\ 10^5$. The evaluation algorithm gives credit for pieces captured, and strategic concepts such as control of an open file and ability to castle. The chess rating of the current best program operating on a particular machine is about 2160 which may be compared with the 2200 of a master player.

For the game of go the situation is completely different; the number of possibilities for each move is on the average more than 200, and an average game is some 250 moves long. This means that the number of blind move possibilities exceeds that for the case of chess before a depth of five moves is reached; four moves is such a small fraction of the total game that a static evaluation algorithm could not distinguish between the good moves and the bad ones. The merest beginner learns a technique (the "ladder") incorporating a forcing sequence of some 30 moves to capture enemy stones. Thus, blind search through all the possible moves and the customary improvements to it is not a promising technique for go. What might be useful are goal oriented searches, where the only candidates for a next move are those which appear likely to advance one particular tactical notion. Then, a whole class of goals would be searched. Evaluation might proceed by comparison of much more general pattern features of the current state of the board or portions of it with appropriate stored patterns. These are much more sophisticated techniques than the ones used in the strongest chess program, though there have been weaker programs which experimented with these kinds of techniques. A successful development of them would have wide application to many more fields. In particular, they represent a kind of reasoning from inference by reference to knowledge base (here a pattern base?) characteristic of many of the problems of this category of Fifth Generation System goals. The rating system for go players in use for centuries would form the basis for accessing the performance of any go playing system to be developed. The current strongest system has a rating some 27 grades below the target level. An intelligent human with some talent for the game might achieve the target level in some two years of play, but there are millions of players for whom this level represents one of life's goals.

- Basic Software Systems

This category includes three research themes:

- Knowledge base management system,
- Problem solving and inference system,
- Intelligent interface system.

These themes are the common themes of the application systems of the previous category, and there is a strong connection between the categories. The emphasis in this category is more general than that of the previous one. It is expected that most applications unique to the Fifth Generation Computer Systems will have a common functional structure using these three themes. The human interacts directly with an intelligent interface system which translates his voice, text, or pictures into a more general machine treatable language format. This translation is done by reference to a knowledge base containing information about sounds, words, and patterns. A problem solving and inference system interprets this translation and produces a series of concrete requests for machine services by reference to a knowledge base system containing information about problems in general, and about the specialized field of the problem in particular. The machine then services this request making use of the resources available to it and processes to be discussed later. The response is reexamined and reinterpreted by the problem solving and inference system into the machine treatable language format (using the problem knowledge base for reference). A possible response may at any time be a request for more specification of the problem, or a statement of inability to perform the service, or perhaps an estimate of the time required to perform such a service. In this process, the constant references to the knowledge bases are handled by the knowledge base management system, which would also have been used in building the base initially and in updating it.

. Knowledge base management system

The goals of the knowledge base management system are:

to build a knowledge base containing information relative to several different fields of expertise, either centralized or distributed, which incorporates learning mechanisms based on inductive inference, and is successfully interfaced with a logical inference eystem,

to build a system capable of storage and retrieval of knowledge consisting of 20,000 rules and 100,000,000 data items, with each item having on the average some 1,000 bytes of data.

To achieve these goals, basic theoretical problems in knowledge representation must be solved. The management system must overcome the problems associated with simultaneous storage of the knowledge, and the rules for handling that knowledge. A system for optimizing the access to specific stored items must be thought out carefully: How does one check that updated knowledge added at a later time is consistent with all the knowledge already in place? The number of combinations which must be checked by logical inference increases rapidly with increasing knowledge base size.

. Problem solving and inference system

The goal of the problem solving and inference research theme is to build an inference machine with a performance of 100 to 1000 mega LIPS. A LIPS (Logical Inference Per Second) is the performance of one syllogistic inference per second. In current computer operations a single such inference is equivalent to 100 or 1000 sequentially executed instructions. This does not mean that the target machine must perform $10^9 . 10^3$ or 10^{12} instructions per second--the target machine is one which does logical inferences more as a basic operation, without the need to step through *1000 separate instructions of the kind* used now. Present generation machines are in the range of 10^4 - 10^5 LIPS, so we are talking about an improvement by a factor of 10,000.

This task has an unsolved theoretical problem at its core, whose solution holds the key to the feasibility of the Fifth Generation Computer System project. One must first understand the nature of problem solving as a process. This will be attacked by establishing a processing model of a problem solving and inference system within which investigation of the problem solving function may be carried on theoretically. Also needed is research on problem solving algorithms, and development of an internal language appropriate to the problem solving function. A collection of such algorithms may itself be organized to form a knowledge base which intelligent programming systems may access effectively. Any internal language developed must support not only functional and logic programming, but also conventional modular programming.

. Intelligent interface system

The goal of the intelligent interface system is to provide the system software backup for all the goals of the themes in the basic application system category discussed earlier. Its ultimate purpose is, as before, to eliminate the language gap between the user and the computer, whether the gap is caused by the difference between natural language and computer language, or by the difference beween speech or image data and the keyboard input characteristic of current machines. Since these ideas have been discussed earlier, a list of the goals should suffice here. The natural language and speech system should satisfy the following requirements:

- handle a vocabulary which includes common and technical terms relevent to the computer and information processing itself, and at least one other branch of scientific or technological knowledge.

- adapt itself to communication with unspecified speakers.

- produce speech output in both Japanese and English.

- process speech input and output on an almost real-time basis, i.e., almost as quickly as required by the normal tempo of speech and hearing.

The picture and image processer should:

- permit a mechanically smooth interaction with the visual data,

- handle pictures at least as complicated as medium small scale machine drawings and medical photographs,

- process pictures rapidly enough to allow a smooth man-machine interface.

The topics which must be researched in order to arrive at these goals would include at least: parsing (syntactic analysis), semantic analysis, discourse analysis, sentence construction, construction of a language data base, natural language processors, multiple language basic grammar generation, phoneme identification, sentence understanding, speech synthesis, recognition of variance among individual speakers, speech understanding in context, picture and image construction, development of algorithms for picture and image generation, development of the technology to generate functioning systems from component parts, construction of picture and image processors, and the study of the interrelation of natural language, picture, and image data.

- New Advanced Architecture

This category includes six research themes:

- Logic programming machine,
- Functional machine,
- Relational algebra machine,
- Abstract data type support machine,
- Data flow machine.
- Innovative von Neumann machine

The discussion up to this point has been concerned for the most part with software, but this category is concerned with the hardware on which the software will run. As discussed earlier, one of the basic conclusions of the Fifth Generation Computer organizing committee is that the new software can not be run effectively on computers which use the current architecture, even if we extrapolate the performance of the current architecture to the levels reachable in the 1990s. The two causes of this are that the current architectures imply programming methods which are too unwieldly, and that the current architectures do not take sufficient advantages of the parallel processing potential of the new VLSI technology.

Most programmers are not aware of the connection between the computer architecture and the nature of their daily programming task. When they translate the

specifications given them by the ultimate program user into a program, they are performing two functions. The first is that they are making a logical analysis of the problem and reducing it to a (usually longer) set of (presumably simpler) logical relationships. These logical relationships then must be ordered to build up to a coherent whole. The second function is that they must then figure out what series of machine instructions will perform the required logical steps. This is because in conventional machine architecture where only one instruction is executed at a time, the programmer must specify the order in which the steps are performed--he controls the execution sequence. In recent years, the programmer has been aided by the construction of higher level languages, in which many kinds of logical functions are translated by the language compiler into a sequence of properly ordered machine instructions. But even here the higher level languages are for the most part still procedural--the programmer must figure out the control flow for the machine. A new computer architecture will offer the possibility of separating the responsibility for the two functions now done by the programmer. The flow of control can be undertaken by the machine and leave the programmer free to worry about the logical analysis. The current development of using ever higher level languages will continue, but the more services the languages perform for the programmer, the more difficult it becomes to understand what will in fact be done by the machine under complicated circumstances. The formal description of the higher level language becomes more complicated (and more necessary). The basic problem with this direction of development is that for many applications, the instruction set executed by the machine hardware is very far away from the functions desired by the programmer. In the case of languages such as LISP, it is well-known that ordinary computers are very slow to process the compiled code, necessitating the use of more specialized ones.

Many of the hardware goals of the Fifth Generation Computer project are about 10,000 times higher than current machines. A good portion of this improvement factor is expected to come from the high degree of parallel processing sought in new computer architecture. The aim is to have the parallel processing done automatically, by the hardware alone. Some of the supercomputer developments in this country focus on parallel processing in ways that are controlled by the programmer. This is an approach designed to achieve useful improvements in a few years; it is much less ambitious than the fundamental revolution sought by the Japanese.

The machine architecture research category contains six different kinds of new hardware development. The complete Fifth Generation Computer System is envisaged as containing a number of them, and calling upon the appropriate processor for each of its specialized functions. The plan is to have a modular system, with standard interfaces between the processors, and a standard core language. In that way, specialized machines may be made with only a few of the basic architectures, or with a specially large version of any set of them. For example, smaller computers would use a firmware base architecture and an innovative von Neumann machine. The powerful large-scale computers would use data flow machines and functional machines. The flexibility of any machine is greatly enhanced by the requirement that a particular machine may make use of the processing facilities of other machines at other sites by appropriate networking. This distributed architecture is the topic of a subsequent research category.

. Logic programming machine

The goals of the logic programming machine theme are:

- construct an expanded PROLOG language for use as a tool in developing a knowledge information processing system (by the end of the initial phase),

- construct and perfect a new predicate logic language which will be stable for a long time period,

- build a logic programming machine capable of 1,000 mega LIPS (Logical Inferences Per Second).

Central to most of the hardware and software tasks of the project is the development of a core, or kernel language, that is appropriate both to the logical functions needed by the software and close to the elementary operations that the hardware can deliver. As mentioned above in the discussion of the applied problem solving system, the initial kernel language for the project is an extension of the language PROLOG. Although it is a language not well-known in this country, it has some features not contained in LISP, the language most commonly used for artificial intelligence work here. First of all, unlike LISP, PROLOG is a nonprocedural language. Second, it is based on logical statements; the name is derived from programming in LOGIC. This gives the language very nice mathematical properties which may be exploited in program verification. Further, the language has pattern matching capability (unification) which is an asset in the composition of data structure and data base search. LISP has some features not possessed by PROLOG, so that the plan is to extend the language to include some of these LISP features. Also sought in the language extension are modularization facilities, and meta structures. The meta structures give the language the power to examine PROLOG source language itself so that programs may be optimized, or be the subject of knowledge base manipulation by other PROLOG programs. It is not yet known how to make these language extensions, but it seems as though doing so spoils some of the nice mathematical properties of the pure language.

Though extended PROLOG is an initial choice of a kernel language, what is sought is a new predicate logic language which has a power of expression approximating that of natural language. Since hardware will be designed around it, the language must be rather well-perfected and stable before that effort begins.

Just as specialized machines are designed to run LISP programs, a new specialized machine architecture will be constructed in the interest of the project's new kernel language. This will be one of the factors in reaching the processing capability of 10,000 times the power (in logical inferences) of current machines.

. Functional machine

The goals of the functional machine theme are to produce the architecture of a series of list processing machines of increasing capability based on successive implementations on firmware, a parallel processing machine, and a data flow machine. The most powerful, the data flow machine, would be several thousand times the capacity of a 4 MIPS general purpose computer. What is sought is an architecture which would support a theoretical functional model, and a programming language suitable for symbolic computation. It would contain such topics of research development as a functional language (including LISP), methods of coding for the firmware, parallel processing, and data flow machine implementations, a method of interconnecting different processors and an associative processor and memory.

. Relational algebra machine

The goal of the relational algebra machine research is to produce a machine architecture for handling data bases and sets using relational algebra as the interface

language. The architecture would be in support of a machine with some 600 processing elements working in parallel. An architecture should be aimed at servicing each of three levels of storage capacity: 100 megabytes for high speed operations, 10 gigabytes for medium speed operations, and 1000 gigabytes for low speed operations.

The content of the research involves:

- the development of an interface language proceding in three stages from relational logic, to relational algebra to basic machine operations,

- development of a data base management system,

- research on algorithms for basic machine operations emphasizing high degrees of parallel processing,

- development of flexible architecture for high speed, high capacity processing utilizing as necessary parallel processing, pipelining, and data flow techniques,

- research on processor elements, memory, and connective hardware,

- development of construction methods for hierarchical memory and memory devices suitable for high speeds and large capacities.

. Abstract data type support machine

The purpose of the abstract data type support system is to develop both computer memory structure and processor functions to modularize the huge and complex software expected to run on the new systems. The goal is to develop two types of abstract data type support machines: one of 100 parallel von Neumann processors, and another of 1000 parallel non-von Neumann processors.

Accompanying the wide range of applications which will run on the new systems is a wide range of data types: numbers, characters, arrays, symbols, graphs, pictures, etc. It would be appropriate to have a language capable of describing all these data types (and more) in some general way, and these considerations give rise to the concept of an abstract data type. Some languages utilizing abstract data type to a limited extent include Xerox's MESA, MIT's CLU, and the U.S. Defense Department's ADA. There are also Japanese efforts in this direction. As in earlier topics in the project, the search for a new language is connected with the design of machine architectures appropriate for the language, or if separate machines are required, of the additional capability of communication among them.

The research topics included in this theme are:

- the development of an experimental abstract data type machine and its language system,

- research into mapping the virtual resource space into the physical resource space (the generalization of MVS page tables),

- garbage collection by hardware (recovery of unused fragmented memory space),

- development of structured memory using multidimensional addressing capability, stacks, heaps, and tags,

- research into a variety of flexible abstract data type architectures with features insuring the ability to coordinate the activity of processors specialized according to data type such as dynamic microprogramability, adjustable widths of registers and data busses, easily restructurable multifold systems, task switching, and distributed processing,

- implementation of an abstract data type language in a parallel processing environment,

- research on memory mapped input-output, upward compability with conventional languages, modularized operating systems, data base management, and distributed processing.

. Data flow machine

The goal of the data flow machine theme is to produce a series of prototype data flow machines culminating in a degree of parallel processing which will achieve a speed of 10,000 MIPS with a memory of up to 10,000 megabytes by coupling some 10,000 processors. As an adjunct to this high-speed computer, another target is to produce a personal data flow machine coupling 32 processors with a memory of 10 megabytes and a speed of 10 MIPS.

Since the data flow machine is envisaged by the project leaders as the probable ultimate type of architecture on which the highest levels of computer will be realizable, perhaps a word is in order about its characteristics. A data flow architecture is one in which the processing at each step is initiated by the availability of the data required for that step. In the architectures of current machines, a calculation, of course, must await the availability of its components, but it is not the completion of the task of producing the components which triggers the execution of the calculation. Rather, the order of the steps is strictly done in advance, no step is started until each previous one is completed, and the programmer, (or his helper, the compiler) makes the order of the steps such that the steps which prepare the components occur in the program before those which do the calculation which depends on them. An analogy may perhaps be made with the most common kind of parallel processing performed in current machine architectures, that of the input/output devices. In this architecture, the CPU does the arithmetic calculations and system control while the channels do the computing functions associated with the input/output devices. The CPU signals the channel to start the input device, then works on some other computation. When the channel is finished, it signals the CPU that the results of the input are now available, and the CPU resumes its calculations on the original problem. Thus, there is a system of starting tasks, waiting, signaling completion and continuing tasks; the exact timing of the execution of tasks depends on what other tasks are simultaneously in the system and may vary from execution to execution of the same program. When this system is extended to include parallel execution of arithmetic and logical tasks, we get the basic ingredient of a data flow machine. Note that this kind of parallelism is quite different from the programmed pipelining used in current high speed array processors; there it is known in advance on which cycle each arithmetic step will complete.

Since the data flow machine is to support the major burden of parallel processing, it would seem better to incorporate this research theme with that of logic programming or relational algebra machines. Until the theoretical basis for the integration of these functions is completed this can not be done, so it is pursued as a separate theme in itself.

The research topics to be covered are quite numerous and include the design of a machine instruction set and high level language appropriate to data flow, determination of overall machine structure, configuring a connected network of memory and processor elements, development of a structured memory, establishment of an activity control system, development of operating system control functions, development of a structure allowing combination with conventional machines and combination with data base management functions, and provision for protection of data or transactions on interruption.

. Innovative von Neumann machine

The goal of the research theme on the innovative von Neumann machine is to produce processors made with chips containing successively 1,000,000 transistors per chip (MARK I) and then 10,000,000 transistors per chip (MARK II). This type of machine retains the original simplicity advantages of the von Neumann architecture, but implemented with highly sophisticated VLSI components. The chip designs would be produced by Computer Aided Design systems run on successively more powerful machines, starting with current machines and ending with other fifth generation computer systems. There will be some attempt to improve the current von Neumann machines by providing features facilitating program writing and debugging, reducing the "semantic gap" by changing the instruction set, and increasing reliability by self-error diagnosis mechanisms. This theme is more evolutionary than the other revolutionary ones, and as such may provide a kind of compatibility with current machines, at least when used in simulation mode, that the newer architectures would lack. The research topics also include development of an architecture data base and development of a chip called "micro 90" characterized by application oriented design.

- Distributed Function Architecture

This category includes five research themes:

- Distributed function architecture,
- Network architecture,
- Data base machine,
- High-speed numerical computation machine,
- High-level man-machine communication system,

The general aim of these research themes is to combine VLSI with the new architectures discussed in the previous category, and study the connection between communication technology and computer technology. This is to provide not only for local networks which have distributed data bases and programs, but for linkages with global networks allowing for such distribution. The description of these themes given in the proceedings does not show a marked difference with a number of the themes discussed earlier. Also, the fact that the name of the category of themes is the same as the name of one of the themes in it indicates some vagueness in the distinctions among the research themes; there is clearly much overlapping or at least areas of common interest; accordingly, the descriptions for this category will be rather brief.

The term "distributed function architecture" is complicated by its use without special qualification to refer to at least three levels of distribution of function:

- relations between a user at his personal computer and a host machine, or even the relations between separate complex computer sites,

- the relations between the different types of processors within the same central computer; for example, the distribution of function among a portions of the system which perform user services, machine services, or general system control,

- the relations between multiprocessing units within the same machine component as a result of the high level of parallel processing.

. Distributed function architecture

The goals of the distributed functional architecture theme are not listed separately as are many of the other themes. Instead, the overall purpose is given as development of a system which assures high reliability, efficiency, simplicity of use and construction, and will provide the flexibility needed to support future technological improvements, a variety of machines, and sophisticated functions. The project requires some kind of local network linking the personal computers of researchers as early as possible. Later, the network will be expanded to a wider range of function and scope with a view to connection to a universal host machine. In the final period, there will be developed a distributed function network with the fifth generation prototype machine at its core.

The research themes include the establishment of a logical model on which to base studies of modular communication, simulation, and system evaluation; invention of an operating system suitable to distributed function(problems of job and task management, error recovery, avoidance of deadlock, and data protection in this new environment are unsolved problems); study of dynamic architectures which respond to changing requirements for resource allocation, change of instruction sets or microcode; methods of implementation on real devices, including use of VLSI. As increasingly advanced and diverse types of machines evolve from the work of other groups on the project, they will be incorporated into increasingly complex structures and networks produced by this group.

. Network architecture

The goals of the network architecture research theme are not stated in terms of the specifications of a target system. It aims, generally, at studying methods of combining computer and communication technologies to make loosely coupled networks of physically separated computer systems. Its research topics include the standardization of network architecture: conception of a unified protocol spanning a variety of machines, terminals, public and private networks, and data types; development of operating system for distributed functions: network job, data, and file management, communication between jobs and distributed data bases; development of techniques for the coding, production, and verification of protocols; multimedia processing techniques for data, voice, picture data, etc.; development of techniques for high speed transmission interface, communication and control, and encryption; optical fiber communication technology; satellite communication technology.

. Data base machine

The goal of the data base machine research theme is to develop a special purpose machine capable of high speed processing of very large data bases. A target machine would have a capacity of 1,000 gigabytes of relational data base and be able to process it at a rate of 10,000 transactions per second. Current large data bases are accessed no faster than 100 transactions per second. The basic model of data base to be supported will be relational, but other models will be available as well. The portion of accesses made

on-line by terminal inquiry will not be provided with large capacity back up memory devices. Current machine architectures have been optimized for the storage and processing of numeric data, and it cannot be said that the input and output capabilities have reached the optimum level. The nature of the architecture and the hardware have forced the software to carry the burdens of the task. It is because of the basic problem of mapping symbolic names from queries onto the memory region, and maintaining such a map in the face of data bases where records may be added, deleted, and referenced in several sequences that current access methods are so slow. Thus, new specialized data base architectures will be required for, say, back end portions of the central processor. Some of the features of a new architecture will be a kind of content addressing scheme which will allow parallel searching mechanisms. There may also be attempts to get both "selection" and "join" primitives into the hardware. Candidates for new architectures will be sought among others in such types as functional algebra machines and associative processors. All architectures will be evaluated with respect to performance including reliability, error-recovery, security.

Other research topics include the study of conversion from, and emulation, of existing nonrelational data bases; the use of artificial intelligence components to handle vague as well as precise queries; research on man-machine interfaces such as an easily usable query language and Japanese itself; studies of distributed data base processing so that the system, not the user, takes care of the complications of remote data, duplicated data, data on different systems, communication protocols, and error recovery; research on methods of applying VLSI and other technologies in the architecture; collection and analysis of information relevent to data base design such as patterns of access or memory structure.

. High-speed numerical computation machine

The goal of the high-speed numerical computation machine theme is to produce a machine specialized to scientific calculation and numerical simulation. One target is to achieve single processor elements capable of up to 100 megaFLOPS (Floating Point Operations per second) using new devices. A second is to combine 1000 processor elements of 4 megaFLOPS each in a parallel processor to achieve a level of 1,000 megaFLOPS. A third is to produce a head per track disk holding up to 60 gigabytes.

This kind of machine would not have to await the 1990s, or the development of futuristic software to be useful. There are scientific and engineering problems to be done now which must be delayed or approached by other means because of the long time required to process them on the current fastest machines. A number of them are brought up in the working group summary report: medium and long range weather forecasting and prediction of typhoon paths; nuclear reactor safety anaylsis and simulation in lieu of dangerous experiments; fusion reactor calculations of instability and energy yield; molecular chemistry calculation of electron orbitals for use in synthesis; aerodynamic flow simulations in lieu of costly wind-tunnel experiments; architectural calculations for earthquake safety design; semiconductor electric circuit analysis; natural resource searches and geological analysis of oil deposits; image processing for research and national surveys. The same kinds of requirements present in this country have led to a project under NASA to build a 1000 megaFLOP machine dedicated to solving Navier Stokes Equations (used for flow and transport problems).

What is needed is an architecture capable of high degrees of automatic parallelism as discussed in the Advanced Architecture research category. The pipelining done in the supercomputers of today such as the CRAY-1 and CYBER 205 is a quite limited form of parallelism and must be controlled by the programmer. Perhaps also user languages may be

found more suitable to that kind of task than FORTRAN. In addition to the computer itself, large amounts of auxilliary storage are needed for some scientific computing applications, and the speed of the processing is limited by the access time of data on magnetic disk storage. Accordingly, access time must be decreased from the current 10 millisecond range to the order of microseconds.

The specific research topics to be examined as a part of this calculator are: high speed logic devices (though the Josephson junction research has presumably been moved out of the Fifth Generation computer project to a separate Super Computer project); high density packing of components and connectors to reduce time delays (multichip hybrids); cooling of high density components; logic specifications for the architecture; parallel processing and its effect on computational algorithms; high level language compilers for vector processors; user interfaces such as sophisticated three-dimensional or graphical displays of final or intermediate results for ease of interpretation.

. High-level man-machine communication system

The goals of the high-level man-machine communication system are to produce devices which input and output characters (including Chinese characters), pictures, images, and speech to interact with the user. The numerical specifications of these devices have been given already in the discussions of the corresponding basic application system themes. An additional goal of this theme is to produce an integrated terminal capable of handling combinations of the above media and based on VLSI chips. Whereas the earlier themes dealt with the problems of theoretical analysis and software, the research in this theme will try to build a device using these theoretical results.

For the case of Chinese character handling, a further research topic in this theme is the development of a machine to translate "kana" (the Japanese phonetic alphabet) into the Chinese characters. It is much easier to input the limited number of kana to a terminal by means of an ordinary keyboard (for which a touch-typing system can be developed), than to input the Chinese characters themselves. Since Japanese is always written without any spaces between the words, a machine to translate kana into characters must do its own lexical parsing of the continuous stream of kana so that it correctly identifies the combinations to be replaced. At the time of the International Conference models of this kind of system were demonstrated. The users seemed to prefer this method of input even though it required a human to examine the text produced and request from the machine additional choices of characters for the many homonyms. Since the time of the Conference advertisements have appeared for compact commercial versions of the product. Thus, part of this research goal have already been accomplished. The idea now would be to put it all on a single chip.

The picture and image research further aims at a pictures with a grid of some 10,000 by 10,000 dots. Devices would first be made to handle a simple on/off switch at each grid dot, but the development would later be expanded to information about intensity of shading and color at each grid dot.

- VLSI Technology

This category has two research themes:

- VLSI architecture,
- Intelligent VLSI CAD system.

Here, CAD refers to Computer Aided Design with specific focus on designing the configurations of gates and their connections on a VLSI chip. Research in this category is of pivotal importance to the fifth generation computer systems because its impact on performance, feasibility of new architectures, and cost of machines to be developed is so great. It has been simple up to now to implement memory on VLSI chips, but the problems of placing many different kinds of function on a single chip in such a way that the full capabilities of the chip are used is much more difficult.

. VLSI architecture

The goal of VLSI architecture theme is to make complete one chip computer architectures for a chip with 10,000,000 transistors per chip. Intermediate targets will include more specialized partial functions on smaller chips, perhaps first the innovative von Neumann machines discussed in the new architecture category. The big gains to be made in the use of VLSI are not simply the result of moving the same methods and algorithms of the integrated circuit era onto the small area of the chip. Rather the architectures and algorithms themselves must be modified to take advantage of the special properties of VLSI.

- On a chip, the communication costs far outweigh the computation costs or to say it in the language of the earlier era, the "wires" connecting the transistors cost more than the transistors themselves. This is the opposite of the ratio in the earlier era, so many previously efficient algorithms become completely wasteful if transcribed unaltered.

- It is very easy to make many repetitions of similarly constructed cells. Algorithms which utilized such designs were previously prohibitively expensive to support.

- Cells with only local communication links use the chip space more efficiently than a structure where many cells must connect to a common bus.

- Data input and output functions consume much less time when a mixture of pipelining and multiprocessing is used.

Previous methods of designing masking patterns for the chips concentrated on hierarchical "top down" or "bottom up" methods. Different approaches, perhaps more oriented toward collections of frames will be attempted. Other research topics to be covered in reaching the theme goals include: construction of a VLSI design rule book so that persons may master the techniques within some six months of college graduation; developing a computerized query system to act as a consultant in VLSI design; development of an architectural data base in which are stored appropriate solutions to specific design problems; development of appropriate coding languages for architectures and VLSI masking patterns.

. Intelligent VLSI CAD system

The goal of the intelligent VLSI CAD system is to make it possible, by use of knowledge bases containing design information, for an application designer to design a masking pattern for a VLSI custom chip containing 1,000,000 transistors within one month. The manufactured chip must be available within three months.

VLSI CAD stands in a special position compared to other software products. A bug in a standard program may be fixed at the cost of a few computer runs and some analysis, but without further computer aid, a bug in a VLSI pattern design may only be found after the

expensive process of manufacturing it is finished. Small sections may be tested separately, but it is the integration of the whole which is the crucial point. Even the computer design of a bridge or building may be tested to some extent by building a small scale model; in integrated circuits this (or even a large scale model!) is harder to make than the original. Thus, CAD is a necessity in the case of ordinary VLSI and even more so as the density of transistors per chip increases. A CAD system can serve many more functions than simply designing the pattern mask. It is usable in logic simulation, circuit simulation, device simulation, process simulation, timing simulation, fault simulation as well as the making, testing, and checking of patterns.

The research topics in this theme include making a standard CAD language in hierarchical levels (system, register transfer, gate and pattern) so that the higher levels will be device independent; development of a CAD architecture data base containing information about architecture, test patterns, circuitry, chip evaluation, design algorithms, libraries of cells and blocks, device information, and rules of manufacture; automatic inclusion of built-in tests in the chip designs; special CAD hardware featuring picture processing, color graphical displays, fast printers and specialized storage devices; an intelligent query system which can use the CAD knowledge base and produce and evaluate its own high level design patterns and algorithms.

- Systematization technology

This category contains four research themes:

- Intelligent programming system,
- Knowledge base design system,
- Systematization technology for computer architecture,
- Data bases and distributed data base system.

What is meant by systematization technology is a set of uniform software systems to aid humans in dealing with computer systems throughout their life cycle, from design through development, maintenance, and management. These software systems would deal in a comprehensive way with all the components of a computer system, from processor elements, through architecture, basic software, and application software. In the course of reaching the end product of the Fifth Generation Computer System, many intermediate computer systems will have to be produced, modified, and discarded. If the process of building systems itself is not systematized, too much time would be lost in this activity. Quite apart from its use in this project, systematization technology is a worthwhile goal. Its use would be a great enhancement to the capabilities of the new machines, and in fact, their usefulness is predicated on the existence of such technology. It is the feature which allows automatic programming, helps build knowledge and data bases, and load balances the local systems by allocation of the components of the distributed architecture.

. Intelligent programming system

The goal of the intelligent programming system is to develop a software product which synthesizes programs meeting specified user requirements, and further verify that the generated program meets the requirements optimally. This goal implies the development of a large-scale program base from which programs and algorithms satisfying basic user requirements may be fetched as needed. It implies also the development of a system to evaluate program performance and a capacity to improve programs through a series of equivalence transformations. The latest stage of the program should include an expert query system addressable in natural language offering consultation in data base management system design, data base management systems, etc.

The results of this research theme is the program that will be accessed by many of the basic application systems of the first research category. It is this programming system that is supposed to remedy one of the great defects of the current (and forthcoming) generation machines, that of the difficulty of writing programs which has provoked the current "software crisis." In an age where the hardware is becoming cheaper and better, the cost of programmers and hence software is becoming higher. (It is not clear whether the average level of programming is rising or falling--there are more training materials and centers of early training, but the number of programmers is so large that we may be dipping into less talented regions of the human ability spectrum.) Automatic programming by the machine itself is the ultimate form of higher level language, provided that the expressiveness of the language in which specifications are made is sufficiently great. The process is further enhanced in query mode, where the machine can request further information to resolve ambiquities.

One of the research topics is the theory of modulary programming and verification. These are lumped together, because at least on the theoretical level, the combining of subprograms each of which performs a known specialized task into a coordinated whole is a kind of inverse function to that of verification of what will be done by a complicated program; the analysis may proceed by breaking the program into its component parts. The theory of combining programs must consider both horizontal and vertical structures. Horizontal structures involve the relationships of elements on the same level, such as two programs, or two sets of specifications. Vertical structures involve the relationships of the separate stages of requirement analysis, user specification and finally the coding of the finished program.

Another research topic in this theme is the theory of program synthesis from user specification. This is a active topic of research both here and in Japan, some of the principles being to find a specification language and a series of transformations of it which will lead continuously and automatically from the specifications to the programs which fulfill them. If this can be done, then modifications to finished programs are then made to the specifications and the process repeated, rather than trying to modify the program directly and introduce unexpected consequences. It is well-known that the cost of modifying a program over the course of its lifetime is several times the cost of writing the original one, and part of this is due to the circumstance that modifications are a rich source of new program errors which require further maintenance. Thus, progress in this area could make a large impact on the "software crisis."

Since there are many ways of writing a program to accomplish a given function, there must be a mechanism to make equivalence transformations between different programs, so that an evaluation may be made based on factors involving current machine resources of speech, memory, or specialized architectures. The rules governing these kinds of design criteria would form part of a knowledge base on program design which operates at a different level from the knowledge bank of standard algorithms. Research topics are provided to cover that area as well as developing systems to maintain, improve, and manage programs.

. Knowledge base design system

The purpose of the knowledge base design system is the development of a knowledge base which contains useful principles and techniques concerning the design, creation, development, and operation of knowledge base systems in general. Thus, there is a parent knowledge base system to aid in the building of daughter knowledge base systems. The specific goals of the parent design system are:

- make simple the creation of a daughter knowledge base system in some high-level field of knowledge capable of offering useful consulation even to sophisticated practitioners,

- the daughter knowledge base system mentioned above must be capable of containing some 20,000 rules,

- the parent system must be capable of assisting in the debugging (at the level of metaknowledge) and partially verifying the programs used in the daughter knowledge base system.

The role of expert systems in the project has been discussed earlier in the basic software system presentation. However, the process of meeting with experts in some technical field, extracting both the information and the rules governing it, placing them in machine usable form, testing the programs in the presence of the experts, and making improvements, is a lengthy one, with many interactions. The techniques used in this process form a skill which has come to be known as "knowledge engineering," and is necessary in the production of expert systems. This skill is also subject to being systematized and put into an expert system. Since it represents knowledge about knowledge it is put in the category of metaknowledge. It is at this level that one can discuss whether the knowledge and the expertise in a particular technical field has been optimally represented in a given implementation of an expert system in this field. At this level one can also discuss verification of the expert system without discussing the particular facts in the technical field. More research must be done to develop a system to express and use metaknowledge. It is quite ambitious to say something which is specific enough to be useful and yet general enough to apply to the wide variety of kinds of information present in desired expert systems.

Other research topics in this theme are the general problems of enlarging an existing knowledge base. What is the best way to write a knowledge acquisition system? In the verification process several questions must be answered. How do we determine that there are now important gaps in the knowledge present, or that new knowledge added is not duplicated or implied by knowledge previously in the system, or that new knowledge is not contradictory to what can be implied by combinations of the knowledge previously in the system? There are also questions of logical completeness of the system's inference rules, particularly in the case of expert systems based on incomplete knowledge, such as medical diagnosis.

. Systematization technology for computer architecture

The theme of systematization technology for computer architecture aims at completing the fifth generation computer system by developing techniques to build up real and virtual systems, to optimize their configuration for load balancing, to construct large scale systems, and to assure their high reliability. The final version of the fifth generation computer system will be made of many software modules, many hardware modules, many VLSI chips, connectors, and cables. It will have to go through many intermediate stages as successive components are readied, installed, tested, repaired, improved, or replaced. To manage all this change it is felt that the very process of assembling the computer and keeping track of the status of the machine and all its parts (and their connections) is one which requires some organized methodology, some standards of documentation and some machine assistance. This research theme aims at meeting these requirements, and thus guaranteeing a level of reliability unreachable by simple human management. Further, since many scattered research groups will need to know information about the current

configuration and its scheduled changes, the local network of research computers will be used as the communication tool. The other tools are yet to be developed or selected.

To use the computer as a tool in this process, some formal systems must be developed. Policy for determining common specifications must be made to make some kind of hierarchy among classes of system components, then the specifications must be written, standardized, and published. Methods must be devised for the evaluation and selection of system components. Special methods must be devised to cope with the enormous size of the fifth generation system, aiming at ultrahigh reliability.

. Data base and distributed data base system

The theme of data bases and distributed data base systems aims at developing techniques of utilizing and integrating two or more data base systems, or two or more knowledge base systems. This is another of the many themes touching on data bases, distributed processing, data base management systems, and knowledge representation theory.

A number of research topics are to be pursued in connection with this theme. Research in data semantics and data models will deal with the changes in the significance of the data as its interpreted context (or the structure of the data base in which it is embedded) changes. This is related to what in artificial intelligence work is known as a "Truth Maintenance System." Another research topic deals with development of a flexible structured data base system which can adapt itself easily to changes of physical storage devices or even changes in the host computer. It will also concern itself with finding ways to have the data base dynamically restructured in response to changes in the use of it by application programs; this will involve some kind of representation of the data which will permit access independent of some rigid scheme of initial organization. This independence would be especially important in the case of nonnumerical data such as pictures, algorithms, etc. This flexible data structure technique must still provide the standard management tasks such as insuring data integrity in the case of multiple users, maintaining records concerning previous versions of the data base, and data security. Another research topic is the development of a system to support scheme design, not only in the initial stages of data base construction, but also when the completed data base must be changed. Other research topics include the development of a system to support data storage, especially addressing the problems of insuring conformity and consistency of newly added data; the development of a question answering system using natural language to help novices with the construction of data bases; development of a distributed data base system with particular emphasis on combining information from different systems into a usable form, regardless of the language, organization, data type, etc., of the separate data bases--this implies not only a high level of data abstraction, but also ready machine access to the meaning of the individual elements within the separate data bases; development of a metacharacter data base system, i.e., one capable of handling any form of data (numbers, voice, pictures, algorithms, circuit designs) with equal facility; development of a data base machine where the above research may be tested, performance improved and special projects undertaken, such as sorting, handling of systolic arrays and directory management.

- Development supporting technology

This research category has only one theme:

. Development support system

AD-A123 948 ONR FAR EAST SCIENTIFIC BULLETIN VOLUME 7 NUMBER 3 2/2
JULY-SEPTEMBER 1982(U) OFFICE OF NAVAL RESEARCH LIAISON
OFFICE FAR EAST APO SAN FRANCISCO 96503 1982

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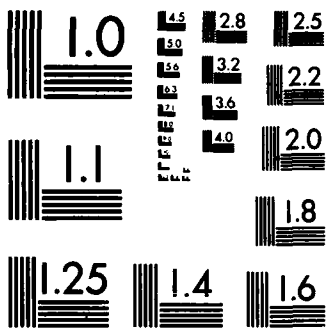

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

This category has much in common with the separate themes of the systematization technology category since it aims at the development of the system as a whole. The emphasis here is on tools to help the individual research efforts rather than the assembly of the system into a single entity. Many of its goals, although they continue throughout the duration of the project, must be implemented at some useful level within the first phase of the research. Here, the idea is to make the tools compatible with the overall designs of the project and subject to the same overall constraints on language, interfaces, documentation, etc. In this way the tools mature along with the project and will form a part of the end result.

There are five research topics in this theme:

- use of VLSI CAD as a supporting tool,
- personal computers for use in research and development,
- computer network,
- support system for software development,
- support system for knowledge base development.

The first topic has a series of subgoals continuing until the end of the project, and starts with work on LSI CAD support systems which have a continuity with current systems. This is necessary to provide some new tools for the initial stage of project research, particularly custom chips for experimental machine models emerging from the research category on new architectures and from early versions of the research personal computers. The research will later lead to VLSI CAD designs, with actual chips to be produced in cooperation with manufacturers.

The personal computers referred to in this theme (and throughout the project) are not time sharing terminals linked to the same computer as is common in many research projects here. They are to be independent computers each with a complement of terminals, memory, and perhaps other input-output devices, such as image processing devices. Besides the extra computing power it gives each researcher, the operating systems can be much simpler, and the data transmission rates for such cases as image or language processing do not impact on other researchers. Since these computers must support knowledge base, language processing, and hardware simulation, possible choices include LISP, PROLOG, or IOTA machines. The LISP machines commercially available do not have hardware support for nondeterminate processing or data abstraction. A PROLOG machine should not be difficult to construct, and it would be good for nondeterminate processing, but experience in Japan with it is insufficient, and the nature of the interface for doing data base or input/output operations and data abstraction is not clear. An IOTA machine should also not be difficult to construct, and since it is a language native to Japan there are reasons to promote it. It is one of the few languages adopted to data abstraction. It has the problems that there is little user experience with it, the generality of its application has not been verified, and, in contrast to PROLOG, it does not support nondeterminate processing. Since there is very little time for research before actual hardware must be distributed to the research groups, the decision was made to make a machine for a language intermediate among the three which could be easily built. The problem with this choice of strategy is that one will not know until quite late whether the new language is dominated by the sum of the advantages of the three languages, or by the sum of their deficiencies.

The computer network is used as a necessary first step in the development of the fifth generation computer system. Specialized machines will be developed independently, then coupled to the network, and later incorporated into a single machine. Of course,

networking will be an important part of the final machines as well, but for different reasons. In the beginning a local network equivalent to the Ether-net will be set up with a distributed operating system. The network will link machines with different functional capabilities, e.g., an inference machine and a knowledge base processor, and also connect to libraries of useful knowledge assembled by the other research groups. Later, when the network development has evolved from a local network to the early stages of the larger global network, the services of a public carrier system will be used, with later development to a high speed, economical communication network.

The software development support package to be provided will include a package of utilities to accommodate the features of the LISP, PROLOG, and IOTA languages, a structured editor, a picture editor and petty printer, a debugging package, verification programs, and a set of management systems for source and object program maintenance.

A knowledge base development support system was recognized as necessary to develop a knowledge base system for public exhibition early in the investigative stages of the project. The work on such a preliminary version of this kind of support system dovetails with the research to be carried on by other groups concerned with this topic. The need to develop such knowledge bases and inquiry systems to produce technically expert systems receives further recognition and support from its presence in the research topics of this theme.

PROBLEMS OF COOPERATION AND COMPETITION

Within Japan

Though the project depends for its success on cooperation among many groups, there are natural tendencies of competition and estrangement among them which must be overcome. An important one is obviously the competition for funds between the Fifth Generation Computer Project and other national projects in a year when there is a call for reducing expenditures. Another problem at the national level has been the lack of cooperation in recent years between the Ministry of Education and the Ministry of International Trade and Industry. The former group controls policies relating to the public universities (such as the University of Tokyo, the university of the project leader), and the latter is the potential funder of the project. The difference of objectives of these two ministries has contributed to the relatively sharp split between university and corporate research. The wide corporate use of academic consultants and private funding of university research projects common in this country are quite limited in Japan. A third problem is that the project organizers are mostly from the Eastern region of Japan; for example, from the government's Electrotechnical Laboratory and the University of Tokyo. There is an ancient rivalry between the Eastern and Western regions of Japan which in this case is overlayed by the distinction between the project insiders and those who will (and should) be brought into the project at a later time; for example, the researchers at the University of Kyoto. Some of them participated in the working groups, but a problem will still be to avoid the image of this being an "Eastern" project. Another gap to be bridged is the reluctance of industrial corporations to join a project which is to them so speculative in nature. Perhaps their role in the early stages needs more clear definition. Certainly as solutions to the major theoretical problems develop, they will want to be as close to the Project as possible so that the chance to develop and produce useful products is not lost. There may very well be at that time a cry to repress publication of project results and a desire on the part of corporations to withhold information regarding their development work from both the project and other participating companies.

These are few of the factional forces which would tend to impede the cohesiveness of the project. However, the management of factionalism is not a new problem in Japan, indeed it may be the commonest problem of all. A glimpse at their success in handling it may perhaps be had in the earlier national projects in which rival companies were induced to join hands in common challenges which were successfully met.

Relations with the United States

A number of questions were raised in the discussion of funding and administration above which pose problems for the project managers in Japan. Some of the same questions may be asked at the international level, where they pose problems for Japan, the United States, and other countries. Specifically the following questions seem worth discussion:

- Does the Fifth Generation Computer Project affect the United States positively, negatively, or not at all?

- Should the United States take a position on the Project?

- Should the United States undertake any action relevent to the Project?

- What action is most appropriate?

Without making any claim to economic expertise it seems clear that the Fifth Generation Computer Project will have a serious adverse effect on the U.S. economy if it results in a perceived technological superiority of Japan over the U.S. in software, hardware, or both. We have seen what the cost to the U.S. economy has been in losing successively the markets in textiles, consumer electronics, steel, and automobiles because of technological and other factors. The influence of superior technology is much more marked in the computer industry, where considering domestic competition alone, new companies with a better idea have caught established companies unawares and taken over substantial chunks of their market share or obsoleted whole product lines overnight. Furthermore, the economic effects on the losers wrought by the sudden appearance of superior technology may be worse in the computer industry since companies must count on increasing sales to cover the large past expenditures in research and development; even if they retain their current sales but lose new customers to a competitor, they fall into financial difficulties. For these reasons, the proportionate losses to be expected in the computer industry should be greater and more precipitous than those experienced in the case of other industries.

Some persons may argue that any basic research is of great benefit to mankind, and that the United States will also benefit from advancing technology regardless of who gets the credit for the discoveries . This may be true in the long run, but the economic losses to be felt in the short run may be quite severe. If this research were in fact being conducted for the benefit of mankind, the United States would be better off if it served mankind itself in this way rather than have another country do so. In any large research project of this kind it is usual and appropriate that individual researchers be motivated by intellectual curiosity and selfless ideals. It seems also usual and appropriate that the agencies funding the research maintain a somewhat harder perspective on the consequences of success and failure for the prosperity of their country.

There are several ways in which the Fifth Generation Computer Project might not result in the technical superiority of Japan. If the project is not funded there is no threat from it and long term research will be conducted principally at academic sites, as in this

country. The U.S. would continue to enjoy its lead in software for a number of years, though hardware competition from Japan would become increasingly severe.

A second possibility for maintaining the U.S. leadership is that the project is fully funded over a sustained period, but that the research is not successful because the problems are too hard for anyone to solve in ten years. Since many portions of the project are concerned with exploring the unknown this is a definite risk. Although the primary goals of the project will remain unattained, the progress assessments at the end of each phase of research will switch to more modest goals, and all the secondary effects of a goal-oriented, coordinated, sustained, and funded program will accrue to Japan. In this case, United States research along the same directions will also show only small progress, but since it is uncoordinated, there will be fewer spinoffs from it. As far as missing the commercially valuable spinoffs from the project, even interfactional warfare on the project would be unlikely to distract the participating companies from keeping their eyes on the ball. Thus, we can argue that even if the research problems prove intractable, Japan will come out ahead of the United States as a result of undertaking them.

A third scenario to consider is that the project is funded, but fails because the Japanese are less competent at this kind of research than Westerners would be. There does seem a tendency to welcome this view among certain sectors of the West who retain an image of the Japanese as "noncreative" or "nonanalytical" (with the corresponding positive attributes research principally for Western researchers). This is not the place to conduct a scholarly discussion of the existence or nonexistence of national characteristics or personality types. Simply speaking of measurable achievements, Japanese researchers do make contributions and with Nobel prizes in other theoretical subjects, their level of technical training seems comparable with the West (often with the same textbooks), they present papers at the same international conferences and seem to be quoted by other authors in the technical literature. In the field at hand, the papers of the working groups shows a mastery of the gist of previous research in the field. Although many of the researchers are newcomers to the field, so that their knowledge of some of the techniques is more vicarious than experiential, this is not a defect in ability, nor one which is irremediable. Japan, with half the population of the United States annually graduates more electrical engineers. It may be said that an industry advances by the combined output of three types of persons: persons of genius, experts in the field, and many persons of lesser ability. Persons of genius seem to be distributed equally over Japan and the West, the West has a rapidly narrowing superiority of experts in the field, and the average workday of the Japanese programmer seems to be longer than that of his Western counterpart. Often described in Western magazines are many factors in Japanese society which lead to conformity and the suppression of individual creativity. These arguments are then used to show why the Japanese are unlikely to be creative in research. Even were these arguments substantial, they seem more relevent to affect the conduct of the average shopgirl or office worker rather than the quality of research of the computer scientist or senior research professor, whose abilities alone place him or her in the 99.9th percentile. These are the persons least likely to follow average patterns of behavior, especially where creativity is concerned. As for the Western magazine articles, it seems as if some of them were not original insights, but had as their source Japanese articles on the same subject. The originals were written by creative Japanese do decry and correct practices inimical to the expression of individuality. Thus, this third scenario seems to the author the least likely to prevail, not only because it underestimates the Japanese, but also because it requires the failure of both the principal research and the spinoff from it.

A fourth scenario is that much advancement is made by the Japanese on the project, but either in the normal process of research in the West or because of the adoption of

similar coordinated projects here, we keep pace with them. The discussion of this scenario is clouded by the fact that in the current open conduct of research, many results are published so that everyone may keep track of the state of the art. If the Japanese continue to publish, then the West can keep pace with them in the same sense that one can say that they have come abreast of current research here. If the Japanese stop publishing crucial results after a few years, then the question of keeping pace acquires more significance. The author is unable to assess whether the normal process of research conducted at all the research centers of the West will lead to the kind of results aimed at by the project in the same length of time. Certainly one would have to weigh the resources of people, expertise, and facilities committed to project goals on both sides. It seems likely that the time to develop a commercial product starting from the same theoretical breakthrough would be less in a highly organized, goal-oriented project, where all team members are using the same notation, hardware, and software, than in the West where all these features differ from laboratory to laboratory. A more active approach would be to organize a similar project of our own, with either collected private or governmental funding. Of all the scenarios thus far, this is the only one where we can affect the outcome by our own actions: all the other leave the Japanese as the only agents in the shaping of the future.

The summary of the discussion up to this point may be stated as follows. Whether or not we take positive action of our own the Japanese will probably make useful progress in the Project goals. If this puts them technologically ahead of the West it will result in their gaining a market edge over the West which will be economically harmful to the United States. Positive independent action by Western countries in a parallel direction could mitigate the negative results of their success.

In any case, the judgement of which of the above scenarios is in fact occurring can only be made if consistent attention is focused on the effort underway in Japan. Even if nothing more substantial is undertaken, what is minimally indicated is the establishment of a program to observe and evaluate the progress being made in Japan against that being made in the West.

The Japanese have invited other countries of the world to participate in the project. Should we take them up on it? Some difficult issues are involved here. To do so would be a way of keeping up with the rest of the project as long as communications remained open. Some of the project writings point out the necessity for Japan to remain in control of the project in this case. Japan would obviously not want to put itself in the position of depending on a foreign country for a crucial resource, but it might allow such participation as long as the project is deriving some benefit. The participating group might find its contribution accepted, but towards the end of the project, as competition stiffens, find no corresponding return of information from Japan. Some other countries have announced their intention to join the project, but the details of their offer or of the terms of acceptance have not yet been determined.

Should we refuse to cooperate? One prominent research group, Massachusetts Institute of Technology, did not attend the International Conference because it anticipated that the information transfer would all go one way, and that they would not learn anything from the Japanese. Explicit government measures discouraging transfering information might be taken, but they risk poisoning relations with the Japanese as well as the research atmosphere in this country. A more positive approach which would tend to limit the outflow of technical information would be to adopt our own long-range program involving principal research centers.

An intermediate course between cooperating and refusing to cooperate would be for

the government to take no official stand, but simply to find a laboratory or two to pursue some research aspects of the project on a private basis. This would keep the lines of communication open without giving massive aid to the project or taking a hostile stance towards it.

A different course of action would be to provide the computer industry with information as to what is going on in Japan, and the possible consequences of prolonged inaction. It seems as if the American computer industry is so busy competing within itself for product advances covering only a short time scale, that it does not notice the large factors just beyond the horizon which may affect it so profoundly. Its attitude of relative smugness with respect to the quality of foreign competition may be subject before long to a rude awakening. There is a distinct role for a research organization which would make timely and reliable information concerning Japanese technological developments available to the public. It is important that this research organization have both language skills in Japanese and knowledge of information processing. These would be the minimum skills required to gather and translate information from Japan. More desirable, however, would be sufficient knowledge of computer technology to be able to evaluate what is being collected, summarize the useful material, and direct it to the appropriate parties. Perhaps such an organization could be initially seed-funded by the government and become strong enough in a few years to earn money from subscribers for services provided to them. Japan has a similar agency, JICST, which gathers material from Western publications and distributes them on-line to a network of users. It also offers supplementary technological translating services.

The author is aware that certain large companies maintain, for their own use, libraries of abstracts and other materials on this subject. This private use of information serves only their own purposes; products, services or markets in which they are not interested at the moment, but which might be important for other companies, or the nation, receive no attention.

The purpose of the research group proposed in the previous paragraphs is to wake up the information processing community to the possibility that they are going to lose their technological leadership and hence their markets. As the messages become louder and louder they may take action to form research groups to address the problems being tackled in the Fifth Generation Computer Project. By the time the handwriting is on the wall, it may be difficult to catch up all at once. Therefore, it would be best for the United States information processing industry if such a long-range research project were begun now in direct competition with the Fifth Generation Computer Project. The U.S. effort could have a different emphasis and its own goals, but it must demonstrate technological equivalence or superiority to retain a world market share. Funding is clearly a problem if the industry itself is not aware of any danger. Perhaps the government could fund a seed study project to plan for such a research effort as was done in Japan, but leave the funding of the research itself to a future decision. Funding on a national scale is called for on a project with a large basic research component, but if necessary one could attempt to coordinate an effort to secure funds from the private sector. Unfortunately, without a definite crisis before our eyes, it will be difficult to argue that there is any necessity for spending money simply because a potential crisis awaits us in the future.

Our current position with respect to Japan in the field of computer technology is very much like our position with respect to the Soviet Union in the sciences before Sputnik. We hear of plans, of funds allocated for research, of growing numbers of trained personnel from a country which we regard as technologically behind us. All is ignored, until one day the world sees an unaccustomed bright dot move across the twilight sky and dip beyond the

horizon. There is suddenly a great national furor about why we were not warned, reforms throughout the educational system, programs to translate Russian technical journals, and finally the commitment of huge sums of money for a ten year moon project in order to catch up. At that point we had to do more than catch up technologically; we also had to restore in the eyes of a sceptical world our credibility as a leader. Thus, our unwillingness to heed warnings from many sources resulted in the necessity of spending tens of billion dollars for what we could have bought with a fraction of that had we acted earlier.

It takes time to get a project conceived, funded, staffed, and moving. If all this by magic were to happen tomorrow we would be almost two years behind the Japanese.

INTERNATIONAL MEETINGS IN THE FAR EAST

1982-1986

Compiled by Seikoh Sakiyama

This list will be updated and augmented in future issues of the *Scientific Bulletin*. The assistance of Australian Academy of Science and the Japan Convention Bureau, in supplying a list of meetings in their countries is deeply appreciated. Readers are asked to notify us of upcoming international meetings in the Far East which have not yet been included in this report.

1982

Date	Title	Site	For information, contact
October 3-6	The 3rd International Dental Congress on Modern Pain Control	Tokyo, Japan	Japan Convention Service, Inc. Nippon Press Center 8F 2-2-1, Uchisaiwai-cho Chiyoda-ku, Tokyo 100
October 10-15	International Iron and Steel Institute 16 Annual Conference	Tokyo, Japan	IISI 16 Committee The Japan Iron and Steel Federation Keidanren Kaikan 1-9-4, Ohtemachi, Chiyoda-ku, Tokyo 100
October 19-21	Energy Conference	Canberra, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
October 20-22	The International Conference on Productivity and Quality Improvement-Study of Actual Cases	Tokyo, Japan	Japan Management Association 1-22, Shiba koen 3-chome Minato-ku, Tokyo 105
October 24-29	The Second International Conference on Stability of Ships and Ocean Vehicles	Tokyo, Japan	Professor S. Motora The Society of Naval Architects of Japan 15-16, Toranomon 1-chome Minato-ku, Tokyo 105
October 25-28	Fourth International Conference on Composite Materials ICCM-IV	Tokyo, Japan	Professor T. Hayashi Japan Society for Composite Materials Business Center for Academic Societies Japan 2-4-16, Yayoi, Bunkyo-ku Tokyo 113

1982, continued

Date	Title	Site	For information, contact
October 25-29	The 14th Plenary Meeting of 150 Technical Committee 17-Steel	Tokyo, Japan	The Iron and Steel Institute of Japan 10F Nippon Bldg., 7-1 Ohtemachi 2-chome Chiyoda-ku, Tokyo 100
November 1-4	International Symposium on Carbon	Toyohashi, Japan	Carbon Society of Japan 1-5-3, Yushima, Bunkyo-ku Tokyo 113
November 6-10	1st National Conference on Power Electronics	Adelaide, Australia	The Conference Manager The Institute of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
November 15-18	The 30th Anniversary Symposium of the Japan Titanium Society	Kobe, Japan	The Japan Titanium Society Konwa Bldg., 1-12-22 Tsukiji, Chuo-ku Tokyo 104
November 17-19	The 3rd JIM (Japan Institute of Metals) International Symposium	Japan (undecided)	The Japan Institute of Metals Aza Aoba, Aramaki Sendai-shi, Miyagi 980
November 17-19	Pan Pacific Synfuels Conference	Tokyo, Japan	Japan Petroleum Institute Chiyoda-Seimei Bldg. 27-12, Nishi-Ikebukuro 3-chome, Toshima-ku Tokyo 117
November 24-26	International Symposium on Nucleic Acid Chemistry	Kyoto, Japan	Secretariat of the International Symposium on Nucleic Acid Chemistry Faculty of Pharmaceutical Sciences Osaka University 1-6, Yamadagaoka, Suita Osaka 565
November 26-December 2	The 7th International Conference on Vacuum Metallurgy	Tokyo, Japan	The Iron and Steel Institute of Japan Keidanren Kaikan 1-9-4, Ohtemachi Chiyoda-ku, Tokyo 100

1982, continued

Date	Title	Site	For information, contact
December 6-8	TENCON 82 VLSI Microcomputer Today and Tomorrow	Hong Kong	Dr. Ronnie K.L. Poon TENCON 82 Chinese University of Hong Kong New Territories, Hong Kong
December 6-10	Chemrawn II	Manila, Philippines	New Frontiers Coordinating Office International Food and Policy Research Institute 1776 Massachusetts Ave. N.W. Washington, D.C. 20036
Undecided	International Conference on Mass Spectroscopy	Hawaii, U.S.A.	Professor T. Tsuchiya Basic Science Lecture Room Chiba Institute of Technology 1-17-2, Tsudanuma Narashino, Chiba 275
Undecided	International Rehabilitation Medicine Association Fourth World Congress	Sydney, Australia	Professor G.G. Burniston Dept. of Rehabilitation Medicine Prince Henry Hospital Little Bay, N.S.W. 2036
Undecided	Workshop on Marine Microbiology	Seoul, Korea	Korea Ocean Research and Development Institute P.O.Box 17, Yang-Jae Seoul, Korea

1983

Date	Title	Site	For information, contact
January 17-19	1st International Buffalo Gourd Conference	Sydney, Australia	Dr. Greg Warnick Primary Energy Australia Pty., Ltd. 1 Queens Avenue, McMahons Point, Sydney N.S.W. 2060 Information provided by: Dr. Aron Roberts Qabel Foundation Inc. Santa Cruz, CA

Date	Title	Site	For information, contact
February 1-11	The 15th Pacific Science Congress	Dunedin, New Zealand	University of Otago P.O. Box 6063 Dunedin, New Zealand
March (tentative)	Conference on Coastal Engineering	Queensland, Australia	Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
May 10-12	International Productive Symposium	Tokyo, Japan	Japan Productivity Center 3-1-1, Shibuya Shibuya-ku, Tokyo 150
May (tentative)	The 36th Annual Metals Congress	Pt. Kembla, Australia	Australian Institute of Metals P.O. Box 1144, Wollongong N.S.W. 2500
May 16-20	The 5th National School and Conference on X-ray Analysis	Melbourne, Australia	Dr. R. A. Coyle X-ray Analytical Association, New South Wales Institution of Technology P.O. Box 90, Parkville Vic 3052
May 16-20 (tentative)	Annual Scientific Meeting of the Australian Society for Microbiology	Brisbane, Australia	The National Secretary Australian Society for Microbiology Inc. 191 Royal Parade Parkville, Vic 3052
May 29-June 3	International Conference on Fluidization	Mie, Japan	Professor D. Kunii Dept. of Chemical Engineering Faculty of Engineering University of Tokyo 7-3-1, Hongo, Bunkyo-ku Tokyo 113
May (tentative)	36th Annual Metals Congress	Pt. Kembla, Australia	Australian Institute of Metals P.O. Box 1144, Wollongong, N.S.W. 2500
June 27-30	4th International Conference on Integrated Optics and Optical Fiber Communication-IOOC'83	Tokyo, Japan	IOOC '83 Business Center for Academic Societies Japan 2-4-16, Yayoi, Bunkyo-ku Tokyo 113

Date	Title	Site	For information, contact
June (tentative)	Biomedical Engineering Conference	Australia (undecided)	The Conference Manager The Institute of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
July 4-5	4th Topical Meeting on Gradient Index Optical Imaging Systems	Kobe, Japan	Nunoi Office Azabudai UNI-house 504 1-1-20, Azabudai Minato-ku, Tokyo 106
August 1-7	International Association for Dental Research	Sydney, Australia	Mr. Scott Gotjamanos Dept. of Pathology Perth Medical Center Verdon Street Nedlands, W.A. 6009
August 17-24	The 4th International Congress of Plant Pathology	Melbourne, Australia	Mr. B. Price Victorian Plant Research Institute Dept. of Agriculture Victoria, Swan Street Burnley, Vic 3121
August 21-26	The Ninth International Congress of Heterocyclic Chemistry	Tokyo, Japan	Dr. T. Kametani Hoshi College of Pharmacy 2-4-41, Ebara Shinagawa-ku, Tokyo 142
August 21-27	The 5th International Congress of Immunology	Kyoto, Japan	The Japanese Society for Immunology Institute of Virus Research Kyoto University Kawaracho, Shogoin Sakyo-ku, Kyoto 606
August 27	Symposium Commemorating the 100th Anniversary of the Mount Krakatau Eruption	Jakarta, Indonesia	Dr. Didin Sastrapradja Indonesian Institute of Sciences LIPI, JL Teuku Chik Ditiro 43 Jakarta
August 27-31	The 25th International Geographical Congress	Sydney, Australia	Australian Academy of Science P.O. Box 783 Canberra, A.C.T. 2601

Date	Title	Site	For information, contact
August 26-September 2	The 18th International Ethological Conference	Brisbane, Australia	Professor E. McBride Dept. of Psychology University of Queensland St Lucia, Qld 4067
August 28-September	The 29th International Congress of Physiology	Sydney, Australia	Australian Academy of Science P.O. Box 783, Canberra A.C.T. 2601
August 28-September 2	The 29th International Congress of Physiology	Sydney, Australia	Australian Academy of Science P.O.Box 783, Canberra A.C.T. 2601
August 28-September 3	The 3rd International Mycological Congress (IMC 3)	Tokyo, Japan	Professor K. Tsubaki Institute of Biological Sciences The University of Tsukuba Sakura-mura, Ibaraki 305
August 29-September 3	Fourth International Symposium on Water-Rock Interaction	Tottori, Japan	Professor H. Sakai Institute of Thermal Spring Research Okayama University Misasa, Tottori 682-02
August (tentative)	International Solar Energy Congress	Perth, Australia	Mr. P. Driver Honorary Secretary P.O. Box 123 Nedlands, W.A. 6009
August 14-19	Computers in Engineering	Australia (undecided)	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
August (tentative)	Hydraulics and Fluid Mechanics Conference	Newcastle, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
September 5-7	International Symposium on Guanidine Compounds	Tokyo, Japan	Institute of Neurobiology Medical School Okayama University Okayama, Japan

1983, continued

Date	Title	Site	For information, contact
September 5-10	IUTAM Symposium on Turbulence and Chaotic Phenomena in Fluids	Kyoto, Japan	Professor T. Tatsumi Dept. of Physics Faculty of Science Kyoto University Sakyo-ku, Kyoto 606
September 22-26	The 4th Asian and Australian Conference ISRRT (International Society of Radiographens and Radiological Technicians	Tokyo, Japan	Mr. Lucky Morimoto The Japan Association of Radiologic Technologists 1-26-7, Shinkawa, Chuo-ku Tokyo 104
September 19-23	The 12th World Energy Conference	New Delhi, India	Dr. R.J. Ramdebough 1620 Eye Street Suite 808 Washington, D.C. 20008
September 22-26	The 4th Asian and Australian Conference ISRT (International Society of Radiologic Technologists)	Tokyo, Japan	Mr. Lucky Morimoto International Department The Japan Association of Radiologic Technologists 26-7, Shinkawa 1-chome Chuo-ku, Tokyo 104
October 2-5	The 3rd International Display Research Conference	Kobe, Japan	Japan Convention Services, Inc. Nippon Press Center 8F. 2-1, Uchisaiwai-cho 2-chome, Chiyoda-ku Tokyo 100
October (tentative)	The 8th International Conference on Calcium Regulating Hormone	Kobe, Japan (tentative)	Professor T. Fujita 3rd Division Dept. of Medicine School of Medicine Kobe University 7-13, Kusunoki-cho Ikuta-ku, Kobe 650
October 29-November 3	The 71st FDI Annual World Dental Congress (Federation Dentaire Internationale)	Tokyo, Japan	Japan Dental Association (Japanese Association for Dental Science) 4-1-20, Kudan-kita Chiyoda-ku, Tokyo 102
November (tentative)	Conference on Microprocessors	Australia (undecided)	The Conference Manager The Institute of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600

1983, continued

Date	Title	Site	For information, contact
November (tentative)	Metal Structures Conference	Brisbane, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
December (tentative)	The 12th International Laser Radar Conference	Melbourne, Australia	Dr. C. Platt, CSIRO Division of Atmospheric Physics P.O. Box 77, Mordiattoc Vic 3195
Undecided	The 13th International Congress of Chemotherapy	Melbourne, Australia	Dr. B. Stratford St. Vincent's Hospital 59 Victoria Parade Fitzroy, Vic 3065

1984

Date	Title	Site	For information, contact
May (tentative)	5th International Soils Expansion Conference	Adelaide, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600
August 24-September 1	The 3rd International Congress on Cell Biology	Kyoto or Kobe, Japan	Japan Society for Cell Biology Shigei Medical Research Institute 2117 Yamada Okayama 701-02

1985

Date	Title	Site	For information, contact
August (tentative)	International Association Hydraulic Resources Conference	Melbourne, Australia	The Conference Manager The Institution of Engineers, Australia 11 National Circuit Barton, A.C.T. 2600

1985, continued

Date	Title	Site	For information, contact
October 15-18	International Rubber Conference	Kyoto, Japan (tentative)	The Society of Rubber Industry, Japan Tobu Bldg., 1-5-26 Motoakasaka, Minato-ku Tokyo 107

1986

Date	Title	Site	For information, contact
(Tentative)	International Microbiological Congress	Perth, Australia	Australian Academy of Science P.O. Box 783, Canberra A.C.T. 2601
May 11-17	Congress of the International Society of Haematology and the International Society of Blood Transfusions	Sydney, Australia	Dr. I. Cooper, President Haematology Society of Australia Cancer Institute 481 Little Londsdale Street, Melbourne Vic 3001

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